UNITED STATES DEPARTMENT OF AGRICULTURE

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Washington, D. C. ▼ January, 1925

CORN AND HOG CORRELATIONS

By

SEWALL WRIGHT, Animal Husbandman
Animal Husbandry Division, Bureau of Animal Industry

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SOURCES AND METHODS OF DETERMINING THE DATA

Corn occupies a dominating position in the agriculture of the United States. Each year the crop is larger than those of all other cereals combined. Of these enormous corn crops only about one-sixth is ordinarily marketed, and much of the marketed corn finds its way back to the farm as either corn or corn meal. It has been estimated by the Bureau of Agricultural Economics [1] that about 40 per cent of the total crop is consumed by hogs, 20 per cent by horses and mules, 15 per cent by cattle, 4 per cent by poultry, 1 per cent by sheep, with an additional 5.5 per cent consumed by stock not on farms. The remaining 14.5 per cent includes 10 per cent for human food, 1.5 per cent exported, and 3 per cent for other uses. Corn is thus largely marketed by feeding to animals.

The corn crop fluctuates greatly from year to year. The number of horses and cattle can not be increased rapidly, or profitably decreased, in keeping with these fluctuations. Hogs, on the other hand, multiply with great rapidity and are ready for market when from 6 months to a year old. Thus consumption by hogs is the most elastic important factor in the disposition of the varying corn crops. One would therefore expect to find close relations between pork production

[1] Yearbook, U. S. Department of Agriculture, 1921, p. 164.

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and prices and the corn situation. The present study was made primarily to discover just what relations existed during a period of what may be called normal conditions. The Civil War and the World War naturally disturbed the normal conditions to a marked extent, especially with regard to prices. The effect of the Spanish War was much less. The period from 1871 to 1915 has thus been chosen for study. The following factors have been considered with respect to corn:

The corn crop, its immediate factors, acreage and yield per acre; and the average farm price of corn. With respect to hogs, the slaughter at large markets, the average weight, the pork production, the average market price, and an average farm price have been considered. In all but the last of these items, the data from the Eastern and from the Western pack have been considered separately. The western pack has, moreover, been dealt with by seasons.

Corn acreage.—The fluctuations are based on the estimates of the Bureau of Crop Estimates.[2] A correction is necessary, however, because of the breaks in these estimates as adjustment was made to each new census. The Bureau of Crop Estimates has made a reestimate for all years between 1889 and 1909, making allowance for the census. For the years between 1870 and 1889, the estimate of the Bureau of Crop Estimates for 1869 and the censuses of 1879 and 1889 have been taken as basic. The average in intervening years has been reestimated by swinging the fluctuations shown by the estimates of the Bureau of Crop Estimates between these decennial figures. The method of doing this is such that the ratio of estimates for successive years is multiplied by a constant factor calculated to make the tenth year agree with the next census. This seems to be the fairest method in view of the fact that the original figures for each year were obtained by the Bureau of Crop Estimates by estimating the percentage changes since the preceding year. The formula for the factor by which the original estimate for any given year (the Xth year) after a census is multiplied to bring about this adjustment is as follows, where C_1 and C_2 are the two census figures between which the crop estimates are to be swung and E_1 and E_2 are the original estimates for the same years:

$$\left(\frac{C_1}{E_1}\right)^{\frac{10-x}{10}}\left(\frac{C_2}{E_2}\right)^{\frac{x}{10}}=\frac{C_1}{E_1}\left(\frac{E_1\,C_2}{C_1\,E_2}\right)^{\frac{x}{10}}$$

This can easily be applied with the help of a table of logarithms. The revised estimates are shown graphically in Figure 1.

Corn yield per acre.—The estimates of the Bureau of Crop Estimates [3] were adopted and are graphically shown in Figure 2.

Corn crop.—The corn crop is simply the product of the acreage and the yield per acre (fig. 3).

Average farm price of corn December 1.—The estimates of the Bureau of Crop Estimates have been adopted (fig. 4). The results would have been essentially the same, so far as the fluctuations are concerned, if an average market price had been used instead of the farm price.

Hog data.—With the exception of the farm price, January 1 (fig. 15), for which the estimates of the Bureau of Crop Estimates

[2] Yearbook of the U. S. Department of Agriculture, 1920, pp. 537–538.
[3] Yearbook, U. S. Department of Agriculture, 1920, pp. 537–538.

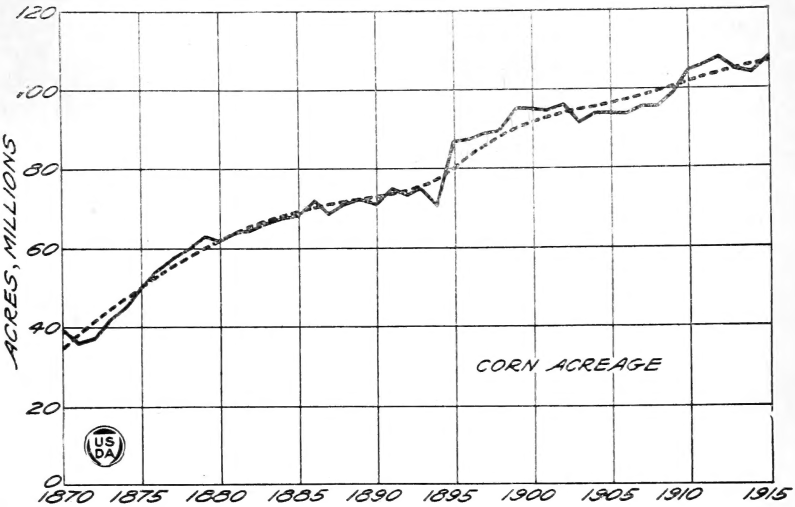

FIG. 1.—The acreage of corn in the United States, 1870 to 1915. The dotted line is the estimate of the trend which has been used in measuring the annual fluctuations

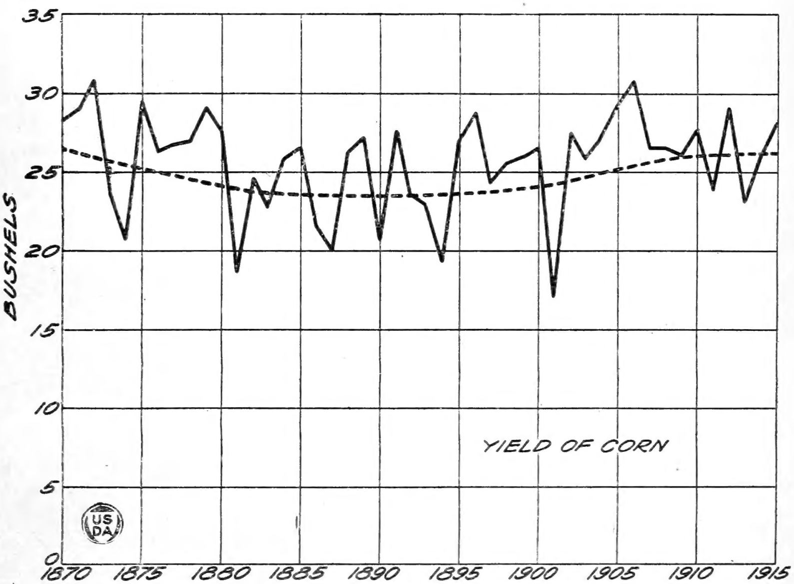

FIG. 2.—The average yield of corn per acre in the United States, 1870–1915, with an estimate of the trend

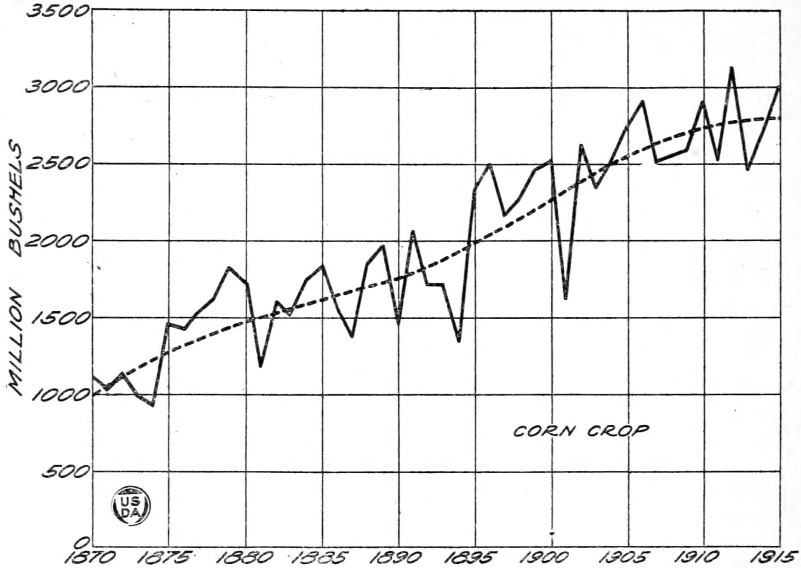

FIG. 3.—Production of corn in the United States, 1870 to 1915, with an estimate of the trend

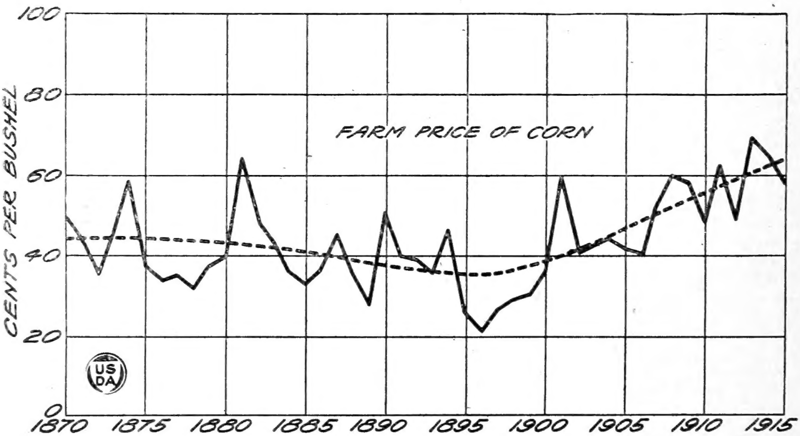

FIG. 4.—The average December 1 farm price of corn in the United States, 1870 to 1915, with an estimate of the trend

have been taken,[4] the figures published annually by the Cincinnati Price Current have been used. These figures go back further than any others which are available.

The western hog pack (fig. 5) has been considered separately from the pack and receipts for slaughter reported for the East (fig. 6). For the latter, data go back only to 1879. The packing year in both cases begins March 1. The western hog pack, as tabulated by the Cincinnati Price Current, meant practically the Corn Belt, while the eastern pack was that of the Atlantic seaboard. The Pittsburgh market was included with the western, but Buffalo with the eastern.

In the earlier years all packing on a large scale was necessarily confined to the winter months. Summer packing was just beginning in 1871. In the case of the western pack it has seemed desirable to treat the two seasons separately (figs. 7 and 8) as well as

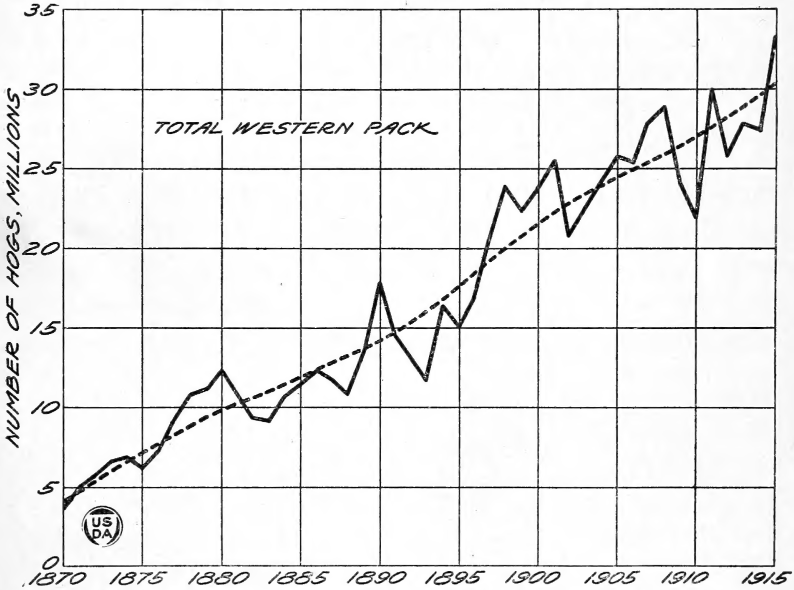

FIG. 5.—The annual wholesale slaughter of hogs at western markets and an estimate of the trend, year beginning March 1, 1870 to 1915

combined, the summer pack consisting of the eight months, March to October inclusive, and the winter pack the 4 months, November to February inclusive, as reported by the Cincinnati Price Current. The average live weight for the two seasons also is available (figs. 9 and 10), extending back to 1871 in the case of winter pack but only to 1889 in the case of the summer pack. The fluctuations in summer and winter pork supply are indicated by the product of pack and live weight (figs. 11 and 12). To obtain actual pork from the commercial pack it would be necessary to multiply by the dressing percentage, but for the present purpose it is unnecessary. The price of western summer and winter hogs, respectively, is shown in Figures 13 and 14. The data for the summer hogs go back only to 1880. The figures from which the graphs are made are given in Table 1.

[4] Yearbook, U. S. Department of Agriculture, 1920, p. 753.

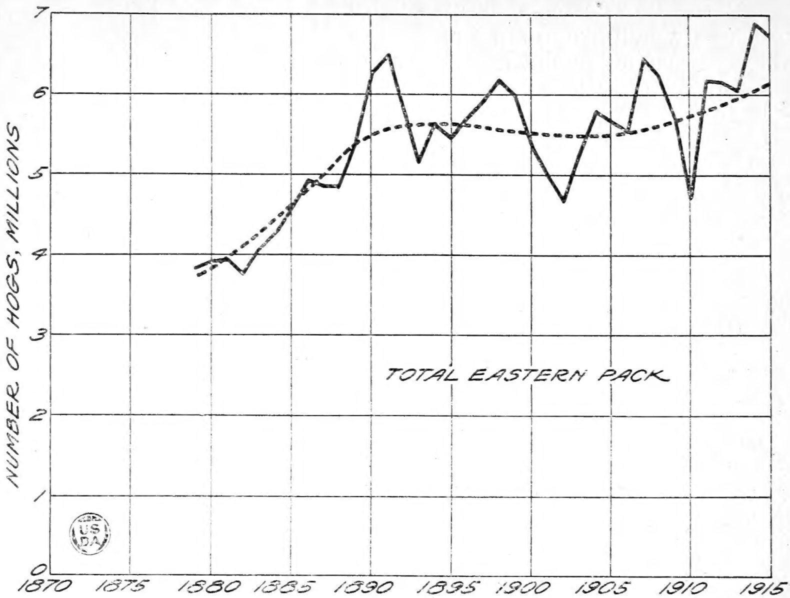

FIG. 6.—The annual wholesale slaughter of hogs at eastern markets and an estimate of the trend, year beginning March 1, 1878 to 1915

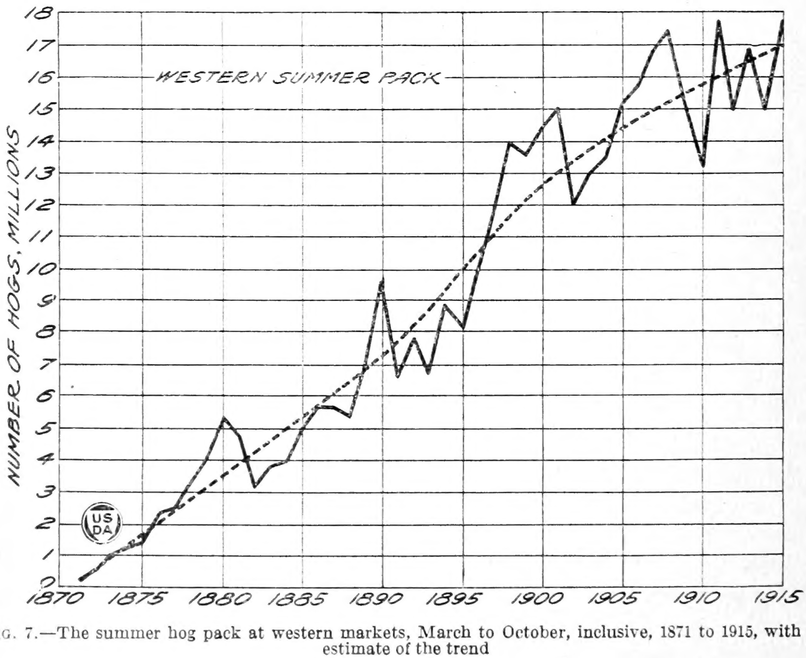

FIG. 7.—The summer hog pack at western markets, March to October, inclusive, 1871 to 1915, with an estimate of the trend

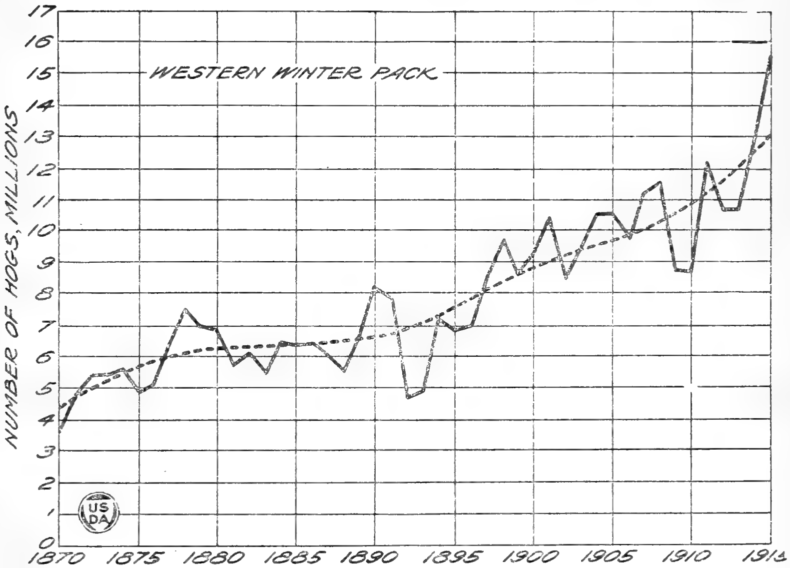

FIG. 8.—The winter hog pack at western markets, November to February, inclusive, 1870 to 1915, with an estimate of the trend

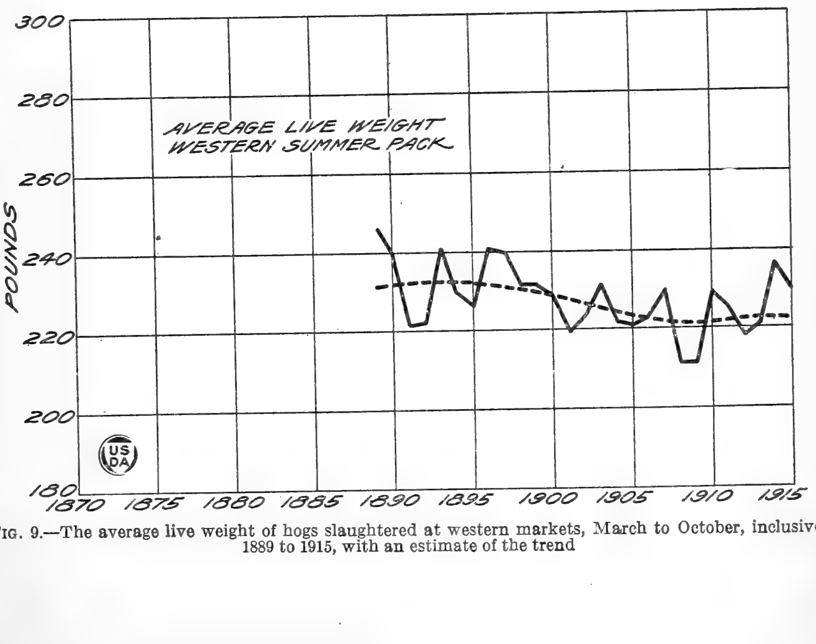

FIG. 9.—The average live weight of hogs slaughtered at western markets, March to October, inclusive, 1889 to 1915, with an estimate of the trend

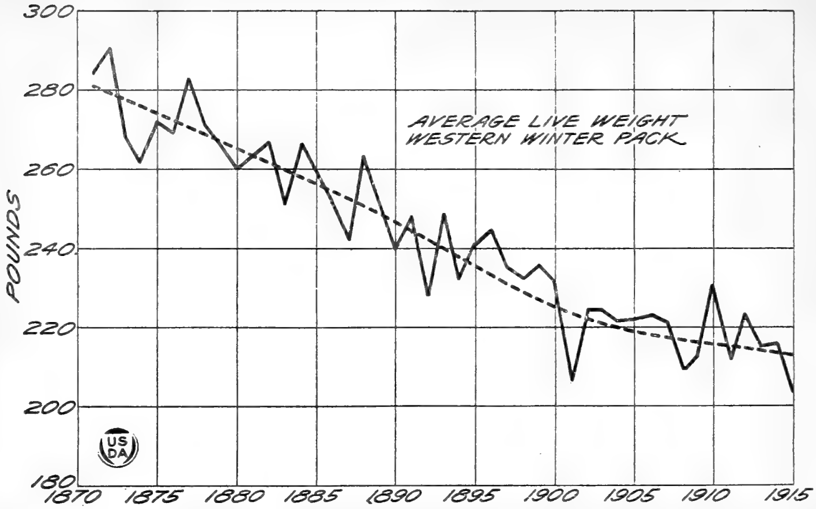

FIG. 10.—The average live weight of hogs slaughtered at western markets, November to February, inclusive, 1871–72 to 1915–16, with an estimate of the trend

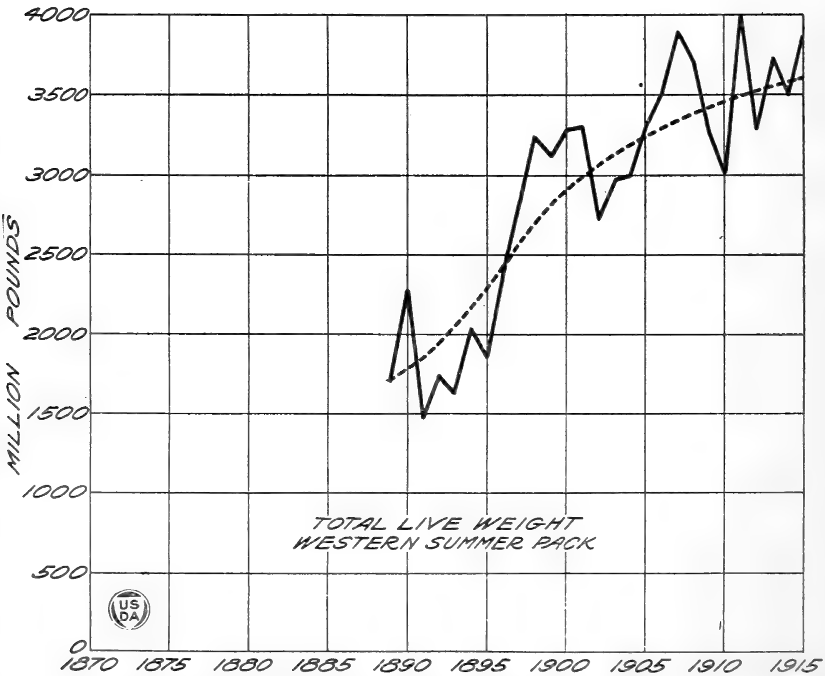

FIG. 11.—The total weight of hogs slaughtered at western markets in the summer season, March to October, inclusive, 1889 to 1915, with an estimate of the trend

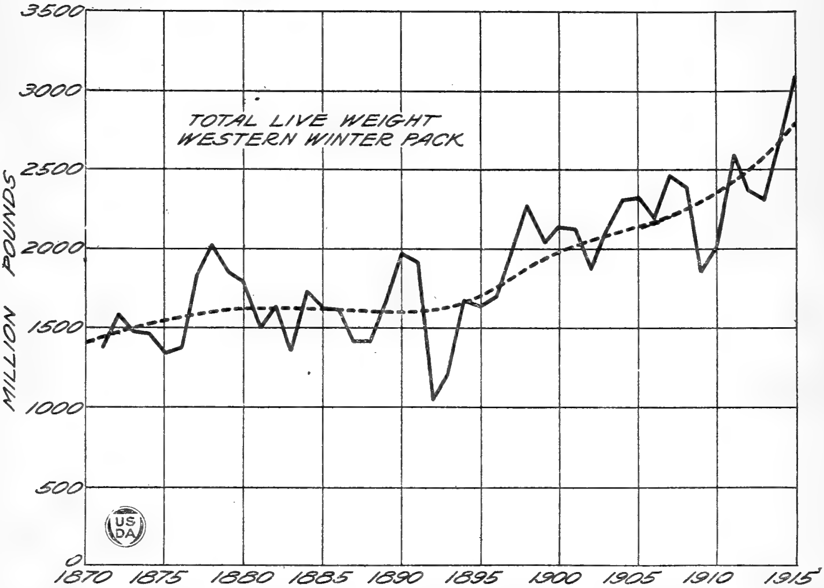

FIG. 12.—The total weight of hogs slaughtered at western markets in the winter season, November to February, inclusive, 1871–72 to 1915–16, with an estimate of the trend

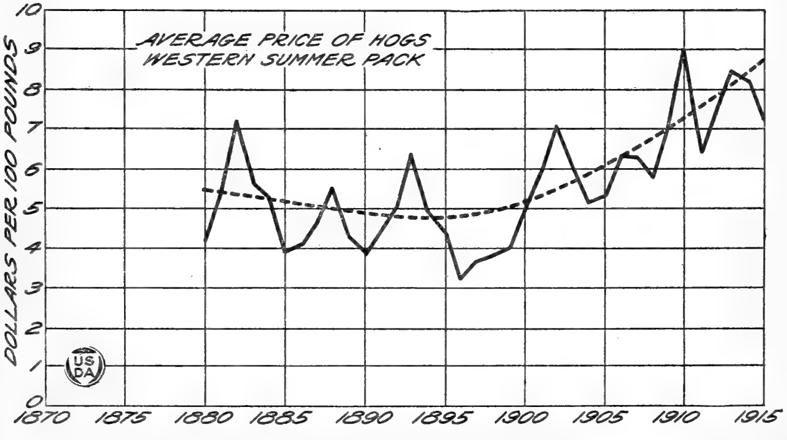

FIG. 13.—The average price of hogs of the western summer hog pack, March to October, inclusive, 1880 to 1915, with an estimate of the trend

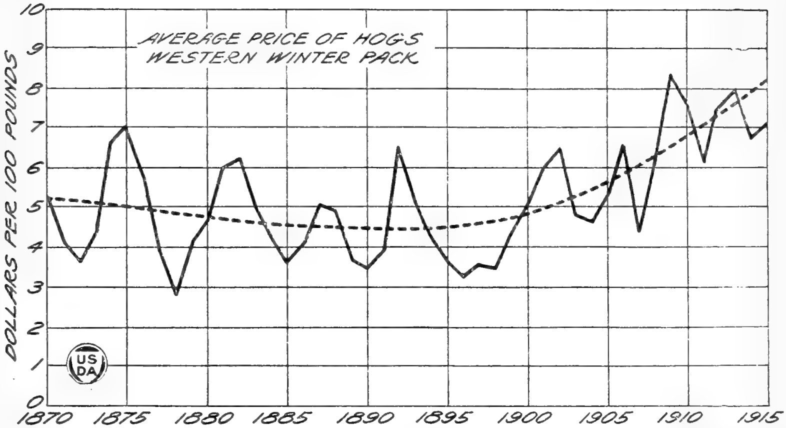

Fig. 14.—The average price of hogs of the western winter hog pack, November to February, inclusive, 1870 to 1915, with an estimate of the trend

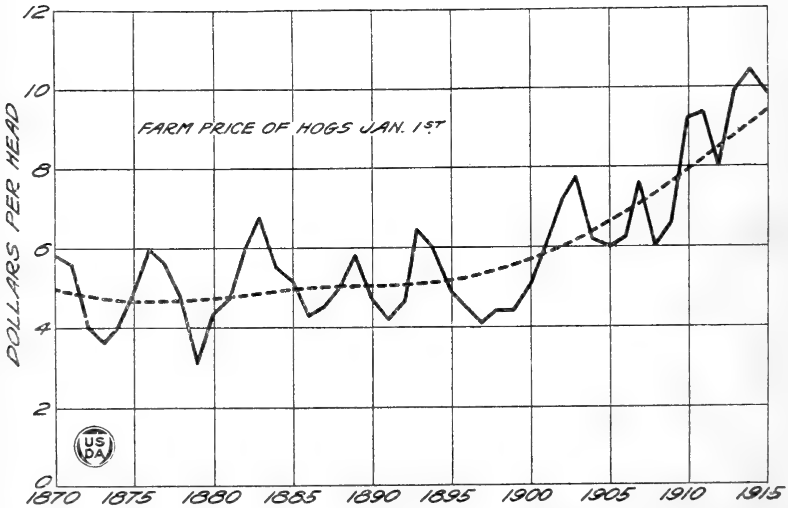

Fig. 15.—The average farm price of hogs per head as of January 1, 1870 to 1915, with an estimate of the trend

TABLE 1.—*The values of the corn and hog variables, 1871 to 1915, inclusive, on which the present investigation is based*

[These values, together with the trends, are shown graphically in Figures 1 to 15, inclusive]

Year	Corn				Western hog pack								Hogs, miscellaneous		
	Acreage	Yield per acre	Crop (bushels)	Price per bushel	Price per 100 pounds		Live weight per hog		Number packed		Weight of pack, pounds		Total number packed		Farm price per head, Jan. 1
					Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Western	Eastern	
	Millions	*Bu.*	*Millions*	*Cts.*			*Lbs.*	*Lbs.*	*Ms.*	*Ms.*	*Millions*	*Millions*	*Ms.*	*Ms.*	
1870	39.3	28.3	1,111	49.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1871	36.1	29.1	1,051	43.4	-----	$4.12	-----	285	250	4,832	-----	1,375	5,082	-----	5.61
1872	37.3	30.8	1,149	35.3	-----	3.73	-----	291	506	5,410	-----	1,572	5,916	-----	4.01
1873	41.8	23.8	995	44.2	-----	4.34	-----	269	1,063	5,466	-----	1,469	6,529	-----	3.67
1874	44.5	20.7	921	58.4	-----	6.66	-----	262	1,200	5,566	-----	1,459	6,767	-----	3.98
1875	49.4	29.5	1,457	36.7	-----	7.05	-----	272	1,262	4,880	-----	1,328	6,142	-----	4.80
1876	54.9	26.2	1,438	34.0	-----	5.74	-----	270	2,308	5,101	-----	1,377	7,409	-----	6.00
1877	57.3	26.7	1,530	34.8	-----	3.99	-----	283	2,543	6,505	-----	1,838	9,049	-----	5.66
1878	59.6	26.9	1,604	31.7	-----	2.85	-----	271	3,378	7,481	-----	3,030	10,859	-----	4.85
1879	62.4	29.2	1,821	37.1	-----	4.18	-----	266	4,051	6,950	-----	1,850	11,002	3,827	3.18
1880	61.8	27.6	1,706	39.6	$4.20	4.64	-----	260	5,324	6,919	-----	1,796	12,243	3,910	4.28
1881	63.2	18.6	1,176	63.6	5.65	6.06	-----	263	4,804	5,748	-----	1,510	10,551	3,920	4.70
1882	64.0	24.6	1,575	48.5	7.20	6.28	-----	267	3,211	6,132	-----	1,637	9,343	3,783	5.97
1883	66.1	22.7	1,500	42.4	5.60	5.18	-----	251	3,781	5,402	-----	1,358	9,183	4,072	6.75
1884	66.9	25.8	1,725	35.7	5.35	4.29	-----	267	4,059	6,460	-----	1,722	10,519	4,208	5.57
1885	69.6	26.5	1,844	32.8	3.90	3.66	-----	259	4,965	6,299	-----	1,631	11,264	4,562	5.02
1886	71.4	22.0	1,571	36.6	4.10	4.19	-----	251	5,644	6,439	-----	1,618	12,083	4,900	4.26
1887	67.7	20.1	1,362	44.4	4.75	5.04	-----	242	5,612	5,921	-----	1,435	11,533	4,857	4.48
1888	70.2	26.3	1,847	34.1	5.58	4.99	-----	263	5,315	5,484	-----	1,445	10,799	4,851	4.98
1889	72.1	27.0	1,946	27.4	4.30	3.66	246	251	6,882	6,664	1,695	1,672	13,545	5,361	5.79
1890	70.4	20.7	1,460	50.0	3.91	3.54	238	240	9,540	8,173	2,275	1,959	17,713	6,253	4.72
1891	74.5	27.6	2,056	39.7	4.48	3.91	222	248	6,696	7,761	1,485	1,922	14,458	6,456	4.15
1892	72.6	23.6	1,714	38.8	5.03	6.54	222	228	7,757	4,634	1,725	1,055	12,391	5,806	4.60
1893	74.4	22.9	1,708	35.9	6.33	5.26	240	248	6,721	4,884	1,616	1,212	11,605	5,184	6.41
1894	69.4	19.3	1,340	45.1	4.98	4.28	230	233	8,812	7,192	2,027	1,674	16,004	5,616	5.98
1895	85.6	27.0	2,311	25.0	4.41	3.68	227	241	8,195	6,816	1,856	1,641	15,011	5,470	4.97
1896	86.6	28.9	2,503	21.3	3.30	3.30	241	245	9,980	6,949	2,403	1,701	16,929	5,747	4.35
1897	88.1	24.3	2,145	26.0	3.70	3.53	239	235	11,760	8,441	2,812	1,987	20,201	5,933	4.10
1898	88.3	25.6	2,261	28.4	3.85	3.52	231	233	13,932	9,720	3,223	2,261	23,652	6,142	4.39
1899	94.9	25.9	2,455	29.9	4.00	4.29	231	236	13,525	8,676	3,130	2,045	22,201	5,970	4.40
1900	95.0	26.4	2,505	35.1	5.12	5.02	229	230	14,323	9,278	3,276	2,137	23,601	5,379	5.00
1901	94.6	17.0	1,607	60.0	5.92	5.97	219	206	15,071	10,340	3,308	2,134	25,412	4,985	6.20
1902	95.5	27.4	2,621	40.0	7.06	6.44	223	224	12,147	8,459	2,710	1,895	20,606	4,641	7.03
1903	90.7	25.8	2,339	42.1	6.11	4.74	231	223	12,877	9,499	2,975	2,123	22,376	5,242	7.78
1904	93.3	27.0	2,521	43.7	5.16	4.67	222	222	13,462	10,457	2,990	2,319	23,918	5,773	6.15
1905	93.6	29.3	2,744	40.7	5.37	5.27	222	222	15,079	10,496	3,343	2,333	25,575	5,698	5.99
1906	93.6	30.9	2,896	39.2	6.33	6.46	223	223	15,736	9,694	3,511	2,161	25,431	5,548	6.18
1907	95.0	26.5	2,512	50.9	6.20	4.47	230	221	16,806	11,175	3,869	2,470	27,981	6,419	7.62
1908	95.6	26.6	2,545	60.0	5.87	5.87	212	209	17,457	11,540	3,697	2,410	28,997	6,201	6.05
1909	98.4	26.1	2,572	58.6	7.42	8.30	212	212	15,437	8,725	3,265	1,853	24,162	5,761	6.55
1910	104.0	27.7	2,886	48.0	9.08	7.58	230	231	13,014	8,741	2,990	2,017	21,756	4,756	9.17
1911	105.8	23.9	2,531	61.8	6.49	6.12	226	212	17,733	12,186	3,999	2,583	29,918	6,165	9.37
1912	107.1	29.2	3,125	48.7	7.47	7.53	218	224	14,965	10,619	3,270	2,373	25,584	6,129	8.00
1913	105.8	23.1	2,447	69.1	8.43	7.98	221	215	16,878	10,744	3,736	2,323	27,622	6,097	9.86
1914	103.4	25.8	2,673	64.4	8.29	6.74	236	216	14,827	12,559	3,504	2,718	27,386	6,859	10.40
1915	106.2	28.2	2,995	57.5	7.33	7.05	228	204	17,128	15,475	3,909	3,153	32,602	6,703	9.87

The object of the present study is to find the way in which the annual fluctuations of these various quantities are related to one another. In order to use the recognized methods of measuring correlation it is necessary to get rid of the long-period trends. As an illustration, consider the case of western winter live weight and pork (figs. 10 and 12). Average live weight has been falling rather steadily since 1870 because of the changes in the type of hog demanded by the market. Pork production has been rising as the population of the country has increased. A direct calculation of the correlation between live weight and pork would thus show a strong negative correlation which, however, would add little to the statement above that these two quantities have followed opposite trends for wholly unrelated reasons.

The objective of the present study is to find the extent to which annual fluctuations in pork supply are determined by the two factors, slaughter and weight. To accomplish this an estimate of the long-time trend and measurement of annual fluctuations from the trend must be made. In the present case a slight positive correlation between average live weight and pork production is found, as is, of course, to be expected.

A thoroughly satisfactory method of estimating the trend is somewhat difficult to find. One method is to take as the trend the average for a certain number of years before and after each successive date. To get a satisfactory trend in this way would probably require the average of at least nine years. The method breaks down for the first and last four years of the period, which seriously cuts down the data available. Another method is to fit some mathematical curve. The choice of such a curve is, however, purely arbitrary. The only measure of its success is the judgment of the eye. It has seemed best, therefore, to fit the trend by eye in the first place, using lines which change in curvature only gradually and not more than four or five times in the 45 years under consideration. Each graph was plotted twice. The trend was drawn in by eye, wholly independently in the two cases. The two estimates never differed greatly. The average between them was adopted as a final estimate and is shown in dotted lines in the figures. The deviations from the trend were then read off from the graphs and reduced to a scale of 0 to 9 for convenience in calculating the correlations.

THE CORRELATIONS

In many cases it is desirable to know not only the relation between two variables in the same year but also the relations one or more years apart. Most of the variables have thus been correlated with each other over a period of five years. Most of the hog variables, for example, have been correlated with the corn variables of the same year, the following year, and the first, second, and third preceding years.

The correlations have been calculated with the help of card punching, sorting, and tabulating machines. The cards which were used have 42 available columns, each of which can be used for one variable. In order, however, to obtain correlations between each variable and five successive years of another, as described above, it is necessary to use three columns for each variable, one column for each of three successive years. This has been done for the four corn variables (acreage, yield, crop, and price) and eight of the hog variables (western slaughter, weight, pork, and cost for both summer and winter). The total western and total eastern slaughter and the January 1 farm price have been punched for only two successive years each. All the possible correlations among these 42 variables have been calculated. Those for which records were not available back to 1870 have been correlated with the others for as great a period as possible. The means and standard deviation are shown in Table 2. The correlations are shown in Tables 3 to 6.

TABLE 2.—*The mean values of the corn and hog variables for the period 1889 to 1913, inclusive, and the standard deviations for this period and for the longer period 1871 to 1913, inclusive, in those cases in which the data were available*

Item	Mean, 1889–1913	Standard deviation from trend, 1889–1913	Standard deviation from trend, 1871–1913
Corn acreage ... million acres	89.8	3.6	3.1
Corn yield per acre ... bushels	25.6	2.9	2.9
Corn crop ... million bushels	2,310	299	260
Corn price per bushel December 1 ... cents	42.6	8.3	8.3
Western pack:			
Summer price per 100 pounds ... dollars	5.61	0.89	[1] 0.90
Winter price per 100 pounds ... do	5.28	0.99	1.03
Summer live weight ... pounds	227.4	7.0	----------
Winter live weight ... do	228.5	7.4	7.4
Summer pack ... thousands	12,591	1,400	1,171
Winter pack ... do	8,875	1,166	984
Weight of summer pack ... million pounds	2,847	313	----------
Weight of winter pack ... do	2,010	253	226
Annual pack:			
Western ... thousands	21,466	2,307	1,947
Eastern ... do	5,709	469	[1] 417
Farm price per head, January 1 ... dollars	6.19	0.96	0.93

[1] 1880–1913.

Owing to the small number of years available for study the probable errors of the correlations are high. The formula for the probable error is $0.6745 \frac{1-r^2}{\sqrt{n}}$ where r is the correlation in question and n is the number of entries. For correlations differing only slightly from 0 based on 43 years the probable error is ± 0.10. If based on only 25 years, as in the case of summer weight and summer pork, the probable error is ± 0.13. These figures are reduced in the case of larger correlations. Correlations of less than $+0.30$ or -0.30 have little absolute significance. Even smaller correlations, however, have some significance relative to each other, so far as they are based on the same data.

In finding the degree one quantity is determined by a number of others, use has been made of Pearson's [5] coefficient of multiple correlation, the square of which measures the degree of determination by the group of factors under consideration.

The deviation from the trend to be expected in the dependent variable can be predicted from the known deviation of the other variables chosen in preceding years by the formula for multiple regression.

In dealing with the nature of the causal relation among the variables in a given correlated system, the method of path coefficients is used.

THE CORN CROP

The corn crop is necessarily completely determined by the acreage and yield. Of the two factors, variations in yield have had a much more important determining influence than variations in acreage. The correlation between crop and yield is $+0.87$, between crop and acreage only $+0.49$. These coefficients indicate 64 per cent determi-

[5] Pearson, Karl, Mathematical Contributions to the Theory of Evolution. Regression, Heredity, and Panmixia. *In* Phil. Trans. Roy. Soc. London, Series A, v. 187, 1896, p. 253–318.

nation by yield, 12 per cent by acreage, and 10 per cent joint determination, due to the correlation of +0.19 between yield and acreage. These coefficients of determination amount to 86 per cent. The remaining 14 per cent must, of course, be spurious and due to such conditions as the combination of the factors by multiplication instead of addition, lack of linearity in the regressions, and inconsistencies in the fitting of the trends. Apportioning it among the two factors we get about 74 per cent determination by yield, 14 per cent by acreage, and 12 per cent joint determination, as the final estimate.

TABLE 3.—*The coefficients of correlation which involve the corn variables. Each corn variable is correlated with the corn variables for the two preceding years, the same year, and the two following years (reading down), with the western hog price, live weight, pack, and pork production for the summer and winter seasons of the preceding year, the same year, and three following years, and with the annual western pack, the annual eastern pack, and the farm price for the preceding, same, and two following years*

[The actual correlations are given in roman; the expected correlations under the system of relations reached in the text are given in italics]

Item	Corn								Hogs													
	Acreage		Yield		Crop		Farm price, Dec. 1		Western (by season)								Annual pack				Farm price, Jan. 1	
									Price		Weight		Pack		Pork		Western		Eastern			
Corn acreage:																						
Second preceding year	+.14	*0*	−.06	*0*	+.04	*0*	−.22	*0*														
Preceding year	+.36	*0*	−.13	*0*	+.01	*0*	−.10	*0*	−.29 −.11	*0* *0*	+.01 +.04	*0* *0*	+.21 +.07	*0* *0*	+.27 +.17	*0* *0*	+.16	*0*	+.09	*0*	−.10	*0*
Same year			+.19	*0*	+.49	*+.45*	−.35	*−.36*	−.21 −.15	*−.05* *−.16*	+.04 +.30	*+.12* *+.34*	+.05 +.01	*−.13* *−.09*	+.02 +.11	*−.09* *0*	+.03	*−.13*	−.03	*+.01*	.00	*−.13*
Following year	+.36	*0*	−.09	*0*	+.02	*0*	−.03	*0*	−.19 −.03	*−.24* *−.18*	+.14 −.01	*+.15* *+.04*	+.31 +.07	*+.29* *+.12*	+.33 +.11	*+.31* *+.13*	+.26	*+.24*	−.03	*+.19*	+.04	*−.21*
Second following year	+.14	*0*	−.16	*0*	−.14	*0*	+.10	*0*	+.18 +.02	*−.11* *−.09*	−.01 +.04	*−.05* *−.03*	+.07 +.13	*+.07* *+.16*	+.08 +.14	*+.05* *+.14*	+.14	*+.13*	−.12	*+.11*	+.17	*−.10*
Third following year									+.17 −07	*−.02* *+.06*	+.16 −.02	*−.10* *−.03*	−.02 +.16	*+.07* *−.01*	+.09 +.16	*+.05* *−.01*						
Corn yield:																						
Second preceding year	−.16	*0*	−.15	*0*	−.11	*0*	00	*0*														
Preceding year	−.09	*0*	−.15	*0*	−.23	*0*	+.18	*0*	−.07 −.10	*0* *0*	−.13 −.11	*0* *0*	+.08 +.25	*0* *0*	+.20 +.22	*0* *0*	+.18	*0*	+.21	*0*	−.22	*0*
Same year	+.19	*0*			+.87	*+.90*	−.77	*−.72*	−.10 −.29	*−.11* *−.32*	+.10 +.64	*+.23* *+.68*	−.18 +.03	*−.25* *−.18*	−.24 +.17	*−.19* *0*	−.14	*−.25*	+.08	*+.03*	−.17	*−.26*
Following year	−.13	*0*	−.15	*0*	−.19	*0*	+.04	*0*	−.46 −.33	*−.47* *−.37*	+.31 −.21	*+.30* *+.09*	+.56 +.18	*+.58* *+.24*	+.55 +.17	*+.61* *+.25*	+.42	*+.48*	+.38	*+.38*	−.36	*−.40*
Second following year	−.06	*0*	−.15	*0*	−.17	*0*	+.32	*0*	+.04 −.07	*−.22* *−.17*	−.10 −.05	*−.11* *−.06*	+.20 +.40	*+.14* *+.32*	+.21 +.33	*+.11* *+.29*	+.34	*+.26*	+.23	*+.23*	−.12	−.18
Third following year									+.15 +.33	*−.04* *+.12*	−.35 −.26	*−.21* *−.05*	+.16 −.04	*+.14* *−.02*	+.17 −.16	*+.09* *−.03*						

TABLE 3.—*The coefficients of correlation which involve the corn variables. Each corn variable is correlated with the corn variables for the two preceding years, the same year, and the two following years (reading down), with the western hog price, live weight, pack, and pork production for the summer and winter seasons of the preceding year, the same year, and three following years, and with the annual western pack, the annual eastern pack, and the farm price for the preceding, same, and two following years*—Continued

[The actual correlations are given in roman; the expected correlations under the system of relations reached in the text are given in italics]

Item	Corn								Hogs													
	Acreage		Yield		Crops		Farm price, Dec. 1		Western (by season)								Annual pack				Farm price, Jan. 1	
									Price		Weight		Pack		Pork		Western		Eastern			
Corn crop:																						
Second preceding year	−.14	*0*	−.17	*0*	−.09	*0*	−.07	*0*														
Preceding year	+.02	*0*	−.19	*0*	−.20	*0*	+.11	*0*	−.19 −.14	*0* *0*	−.11 −.14	*0* *0*	+.13 +.25	*0* *0*	+.28 +.27	*0* *0*	+.20	*0*	+.19	*0*	−.23	*0*
Same year	+.49	*+.45*	+.87	*+.90*			−.80	*−.80*	−.18 −.24	*−.12* *−.36*	+.18 +.64	*+.26* *+.76*	−.22 −.08	*−.28* *−.20*	−.24 +.13	*−.21* *0*	−.19	*−.28*	−.01	*+.03*	−.10	*−.29*
Following year	+.01	*0*	−.23	*0*	−.20	*0*	+.09	*0*	−.47 −.29	*−.53* *−.41*	+.37 −.17	*+.33* *+.10*	+.61 +.21	*+.65* *+.27*	+.64 +.26	*+.68* *+.28*	+.49	*+.54*	+.30	*+.42*	−.31	*−.47*
Second following year	+.04	*0*	−.11	*0*	−.09	*0*	+.23	*0*	+.03 −.06	*−.24* *−.19*	−.13 −.04	*−.12* *−.07*	+.19 +.42	*+.15* *+.36*	+.21 +.38	*+.12* *+.32*	+.33	*+.29*	+.17	*+.25*	−.06	*−.22*
Third following year									+.16 +.28	*−.04* *+.13*	−.32 −.27	*−.23* *−.06*	+.18 −.02	*+.15* *−.02*	+.17 −.10	*+.10* *−.03*						
Corn price:																						
Second preceding year	+.10	*0*	+.32	*0*	+.23	*0*	−.11	*0*														
Preceding year	−.03	*0*	+.04	*0*	+.09	*0*	+.08	*0*	+.01 +.01	*0* *0*	+.14 −.02	*0* *0*	+.19 +.08	*0* *0*	+.02 +.06	*0* *0*	+.14	*0*	.00	*0*	+.07	*0*
Same year	−.35	*−.36*	−.77	*−.72*	−.80	*−.80*			+.18 +.40	*+.15* *+.45*	−.43 −.64	*−.32* *−.66*	+.31 +.14	*+.24* *+.16*	+.30 −.06	*+.16* *−.01*	+.25	*+.23*	+.07	*−.07*	+.25	*+.37*
Following year	−.10	*0*	+.18	*0*	+.11	*0*	+.08	*0*	+.66 +.56	*+.66* *+.51*	−.51 +.05	*−.42* *−.13*	−.58 −.32	*−.56* *−.34*	−.72 −.41	*−.62* *−.35*	−.55	*−.52*	−.40	*−.49*	+.55	*+.59*
Second following year	−.22	*0*	00	*0*	−.07	*0*	−.11	*0*	+.29 +.20	*+.31* *+.24*	+.13 −.01	*+.15* *+.09*	−.33 −.52	*−.23* *−.46*	−.35 −.51	*−.19* *−.41*	−.45	*−.39*	−.35	*−.33*	+.24	*+.27*
Third following year									−.04 −.31	*+.05* −.16	+.22 +.20	*+.29* +.07	−.34 −.01	*−.19* *+.02*	−.34 +.05	*−.12* *+.04*						

TABLE 4.—*The coefficients of correlation which involve the western summer hog price, live weight, pack, and pork production. Each is correlated with the corn variables of three preceding years, the same year and the following year (reading down) and with the hog variables of the two preceding, the same and one or two following years*

[The summer correlation is given above, the winter below, in those cases in which the year is broken into seasons. The actual correlations are given in roman, the expected in italics]

Item	Corn								Hogs															
	Acreage		Yield		Crop		Farm price, Dec. 1		Western (by season)								Annual pack				Farm price, Jan. 1	
									Price		Weight		Pack		Pork		Western		Eastern			
Western summer hog price:																						
Third preceding year	+.17	*−.02*	+.15	*−.04*	+.16	*−.04*	−.04	*+.05*														
Second preceding year	+.18	*−.11*	+.04	*−.22*	+.03	*−.24*	+.29	*+.31*	−.26	*−.14*	−.31	*−.32*	+.44	*+.19*	+.26	*+.12*	+.50	*+.27*	+.34	*+.13*	−.17	*−.07*
									−.11	*−.03*	−.19	*−.31*	+.51	*+.28*	+.46	*+.19*						
Preceding year	−.19	*−.24*	−.46	*−.47*	−.47	*−.53*	+.66	*+.66*	+.24	*+.31*	−.68	*−.66*	+.18	*+.05*	−.04	*−.08*	+.03	*−.06*	−.09	*−.22*	+.56	*+.56*
									+.76	*+.65*	−.58	*−.57*	−.18	*−.16*	−.36	*−.29*						
Same year	−.21	*−.05*	−.10	*−.11*	−.18	*−.12*	+.18	*+.15*			−.12	*−.09*	−.54	*−.57*	−.63	*−.56*	−.59	*−.69*	−.70	*−.68*	+.77	*+.80*
									+.69	*+.64*	+.14	*−.06*	−.50	*−.63*	−.55	*−.61*						
Following year	−.29	*0*	−.07	*0*	−.19	*0*	+.01	*0*	+.24	*+.31*	+.24	*+.35*	−.31	*−.40*	−.25	*−.31*	−.20	*−.38*	−.24	*−.30*	+.04	*+.12*
									−.09	*+.01*	−.07	*+.10*	−.08	*−.25*	−.11	*−.21*						
Second following year									−.26	*−.14*	−.04	*+.04*	−.25	*−.07*	−.37	*−.06*						
									−.34	*−.20*	+.04	*−.02*	+.11	*+.17*	+.14	*+.16*						
Average western summer weight:																						
Third preceding year	+.16	*−.10*	−.35	*−.21*	−.32	*−.23*	+.22	*+.29*														
Second preceding year	−.01	*−.05*	−.10	*−.11*	−.13	*−.12*	+.13	*+.15*	−.04	*+.04*	−.61	*−.58*	−.19	*+.02*	−.24	*−.10*	−.14	*+.01*	−.02	*−.08*	+.12	*+.22*
									+.13	*+.30*	−.24	*−.28*	−.01	*−.01*	−.13	*−.08*						
Preceding year	+.14	*+.15*	+.31	*+.30*	+.37	*+.33*	−.51	*−.42*	+.24	*+.35*	+.05	*+.13*	−.38	*−.35*	−.34	*−.31*	−.51	*−.53*	−.46	*−.35*	+.43	*+.35*
									+.33	*+.33*	+.21	*+.33*	−.61	*−.59*	−.58	*−.48*						
Same year	+.04	*+.12*	+.10	*+.23*	+.18	*+.26*	−.43	*−.32*	−.12	*−.09*			−.02	*−.10*	+.17	*+.11*	+.01	*−.05*	−.10	*+.04*	−.34	*−.36*
									−.49	*−.47*	+.48	*+.49*	−.06	*+.01*	+.15	*+.13*						
Following year	+.01	*0*	−.13	*0*	−.11	*0*	+.14	*0*	−.68	*−.66*	+.05	*+.13*	+.48	*+.40*	+.53	*+.41*	+.67	*+.68*	+.59	*+.56*	−.69	*−.70*
									−.63	*−.67*	−.11	*−.04*	+.78	*+.80*	+.83	*+.76*						
Second following year									−.31	*−.32*	−.61	*−.58*	+.25	*+.42*	+.12	*+.28*						
									+.07	*+.07*	−.07	*−.18*	+.19	*+.27*	+.20	*+.24*						

TABLE 4.—*The coefficients of correlation which involve the western summer hog price, live weight, pack, and pork production. Each is correlated with the corn variables of three preceding years, the same year and the following year (reading down) and with the hog variables of the two preceding, the same and one or two following years*—Continued

[The summer correlation is given above, the winter below, in those cases in which the year is broken into seasons. The actual correlations are given in roman, the expected in italics]

Item	Corn: Acreage	Corn: Yield	Corn: Crop	Corn: Farm price, Dec. 1	Hogs: Western (by season): Price	Hogs: Western (by season): Weight	Hogs: Western (by season): Pack	Hogs: Western (by season): Pork	Hogs: Annual pack: Western	Hogs: Annual pack: Eastern	Hogs: Farm price, Jan 1
Western summer pack:											
Third preceding year	-.02 *+.07*	+.16 *+.14*	+.18 +.15	-.34 *-.19*	---	---	---	---	---	---	---
Second preceding year	+.07 *+.07*	+.20 *+.14*	+.19 *+.15*	-.33 *-.23*	-.25 *-.07* -.23 *-.20*	+.25 *+.42* +.22 *+.24*	+.17 *-.04* +.05 *+.01*	+.33 *+.05* +.16 *+.07*	+.13 *-.02*	+.14 *+.07*	-.27 *-.16*
Preceding year	+.31 *+.29*	+.56 *+.58*	+.61 *+.65*	-.58 *-.56*	-.31 *-.40* -.45 *-.60*	+.48 *+.40* +.50 *+.55*	+.22 *+.02* +.32 *+.26*	+.27 *+.10* +.45 *+.38*	+.29 *+.16*	+.16 *+.30*	-.40 *-.56*
Same year	+.05 *-.13*	-.18 *-.25*	-.22 *-.28*	+.31 *+.24*	-.54 *-.57* -.25 *-.27*	-.02 *-.10* -.33 *-.25*	--- +.63 *+.54*	+.96 *+.93* +.55 *+.45*	+.90 *+.90*	+.56 *+.54*	-.35 *-.39*
Following year	+.21 *0*	+.08 *0*	+.13 *0*	+.19 *0*	+.18 *+.05* +.24 *+.17*	-.38 *-.35* +.01 *-.10*	+.22 *+.02* +.20 *+.04*	+.03 *-.07* +.12 *+.01*	+.19 *+.03*	+.07 *+.02*	+.21 *+.14*
Second following year	---	---	---	---	+.44 *+.19* +.44 *+.19*	-.19 *+.02* -.21 *+.03*	+.17 *-.04* -.15 *-.26*	+.10 *-.03* -.25 *-.24*	---	---	---
Western summer pork:											
Third preceding year	+.09 *+.05*	+.17 *+.09*	+.17 *+.10*	-.34 *-.12*	---	---	---	---	---	---	---
Second preceding year	+.08 *+.05*	+.21 *+.11*	+.21 *+.12*	-.35 *-.19*	-.37 *-.06* -.18 *-.13*	+.12 *+.28* +.20 *+.17*	+.10 *-.03* -.10 *+.01*	+.19 *+.02* -.01 *+.05*	+.02 *-.01*	+.09 *+.05*	-.21 *-.11*
Preceding year	+.33 *+.31*	+.55 *+.61*	+.64 *+.68*	-.72 *-.62*	-.25 *-.31* -.43 *-.50*	+.53 *+.41* +.72 *+.59*	+.03 *-.07* +.09 *+.13*	+.18 *+.03* +.24 *+.27*	+.06 *+.03*	-.02 *+.21*	-.30 *-.46*
Same year	+.02 *-.09*	-.24 *-.19*	-.24 *-.21*	+.30 *+.16*	-.63 *-.56* -.42 *-.35*	+.17 *+.11* -.29 *-.14*	+.96 *+.93* +.66 *+.52*	--- +.63 *+.45*	+.91 *+.84*	+.56 *+.52*	-.50 *-.44*
Following year	+.27 *0*	+.20 *0*	+.28 *0*	+.02 *0*	-.04 *-.08* +.11 *+.03*	-.34 *-.31* +.02 *-.10*	+.27 *+.10* +.34 *+.20*	+.18 *+.03* +.24 *+.16*	+.29 *+.17*	+.22 *+.13*	+.04 *0*
Second following year	---	---	---	---	+.26 *+.12* +.47 *+.19*	-.24 *-.10* -.25 *-.01*	+.33 *+.05* -.12 *-.19*	+.19 *+.02* -.22 *-.18*	---	---	---

TABLE 5.—*The coefficients of correlation which involve the western winter hog price, live weight, pack, and pork production. Each is correlated with the corn variables of three preceding years, the same year, and the following year (reading down) and with the hog variables of the two preceding, the same and one or two following years*

[The summer correlation is given above, the winter below in those cases in which the year is broken into seasons. The actual correlations are given in roman, the expected in italics]

Item	Corn								Hogs													
	Acreage		Yield		Crop		Farm price, Dec. 1		Western (by season)								Annual pack				Farm price, Jan. 1	
									Price		Weight		Pack		Pork		Western		Eastern			
Western winter hog price:																						
Third preceding year	−.07	*+.06*	+.33	*+.12*	+.28	*+.13*	−.31	*−.16*	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Second preceding year	+.02	*−.09*	−.07	*−.17*	−.06	*−.19*	+.20	*+.24*	−.34	*−.20*	+.07	*+.07*	+.44	*+.19*	+.47	*+.19*	+.49	*+.30*	+.44	*+.20*	−.40	*−.25*
									−.32	*−.25*	−.11	*−.14*	+.48	*+.33*	+.47	*+.28*						
Preceding year	−.03	*−.18*	−.33	*−.37*	−.29	*−.41*	+.56	*+.51*	−.09	*+.01*	−.63	*−.67*	+.24	*+.17*	+.11	*+.03*	+.23	*+.20*	+.19	*+.03*	+.15	*+.23*
									+.36	*+.32*	−.56	*−.53*	+.20	*+.17*	+.02	*+.03*						
Same year	−.15	*−.16*	−.29	*−.32*	−.24	*−.36*	+.40	*+.45*	+.69	*+.64*	−.49	*−.47*	−.25	*−.27*	−.42	*−.35*	−.44	*−.45*	−.56	*−.54*	+.90	*+.92*
									...	...	−.32	*−.35*	−.58	*−.53*	−.68	*−.59*						
Following year	−.11	*0*	−.10	*0*	−.14	*0*	+.01	*0*	+.76	*+.65*	+.33	*+.33*	−.45	*−.60*	−.43	*−.50*	−.48	*−.66*	−.60	*−.59*	+.56	*+.45*
									+.36	*+.32*	+.18	*+.14*	−.45	*−.54*	−.42	*−.48*						
Second following year	...	...	...	...	...	...	...	...	−.11	*−.03*	+.13	*+.30*	−.23	*−.20*	−.18	*−.13*	...	...	...	...	...	...
									−.32	*−.25*	+.09	*+.06*	+.11	*+.11*	+.14	*+.12*						
Average western winter weight:																						
Third preceding year	−.02	*−.03*	−.26	*−.05*	−.27	*−.06*	+.20	*+.07*	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Second preceding year	+.04	*−.03*	−.05	*−.06*	−.04	*−.07*	−.01	*+.09*	+.04	*−.02*	−.07	*−.18*	−.21	*+.03*	−.25	*−.01*	−.07	*+.05*	−.15	*+.01*	+.06	*+.04*
									+.09	*+.06*	−.18	*−.12*	+.04	*+.04*	−.01	*+.01*						
Preceding year	−.01	*+.04*	−.21	*+.09*	−.17	*+.10*	+.05	*−.13*	−.07	*+.10*	−.11	*−.04*	+.01	*−.10*	+.02	*−.10*	−.10	*−.16*	+.01	*−.10*	+.12	*+.13*
									+.18	*+.14*	−.14	*+.07*	−.25	*−.18*	−.24	*−.15*						
Same year	+.30	*+.34*	+.64	*+.68*	+.64	*+.76*	−.64	*−.66*	+.14	*−.06*	+.48	*+.49*	−.33	*−.25*	−.29	*−.14*	−.31	*−.26*	−.19	*−.01*	−.05	*−.26*
									−.32	*−.35*	...	...	−.18	*−.20*	+.08	*+.05*						
Following year	+.04	*0*	−.11	*0*	−.14	*0*	−.02	*0*	−.58	*−.57*	+.21	*+.33*	+.50	*+.55*	+.72	*+.59*	+.52	*+.58*	+.40	*+.46*	−.54	*−.54*
									−.56	*−.53*	−.14	*+.07*	+.45	*+.45*	+.42	*+.44*						
Second following year	...	...	...	...	...	...	...	...	−.19	*−.31*	−.24	*−.28*	+.22	*+.24*	+.20	*+.17*	...	...	...	...	...	...
									−.11	*−.14*	−.18	*−.12*	+.37	*+.38*	+.29	*+.33*						

TABLE 5.—*The coefficients of correlation which involve the western winter hog price, live weight, pack, and pork production. Each is correlated with the corn variables of three preceding years, the same year, and the following year (reading down) and with the hog variables of the two preceding, the same and one or two following years*—Continued

[The summer correlation is given above, the winter below in those cases in which the year is broken into seasons. The actual correlations are given in roman, the expected in italics]

Item	Corn: Acreage		Corn: Yield		Corn: Crop		Corn: Farm price, Dec. 1.		Hogs: Western (by season): Price		Hogs: Western (by season): Weight		Hogs: Western (by season): Pack		Hogs: Western (by season): Pork		Hogs: Annual pack: Western		Hogs: Annual pack: Eastern		Hogs: Farm price, Jan. 1.	
Western winter pack:																						
Third preceding year	+.16	*−.01*	−.04	*−.02*	−.02	*−.02*	−.01	*+.02*														
Second preceding year	+.13	*+.16*	+.40	*+.32*	+.42	*+.36*	−.52	*−.46*	+.11	*+.17*	+.19	*+.27*	−.15	*−.26*	−.12	*−.19*	−.26	*−.36*	−.35	*−.19*	+.25	*+.14*
									+.11	*+.11*	+.37	*+.38*	−.36	*−.38*	−.28	*−.27*						
Preceding year	+.07	*+.12*	+.18	*+.24*	+.21	*+.27*	−.32	*−.34*	−.08	*−.25*	+.78	*+.80*	+.20	*+.04*	+.34	*+.20*	+.27	*+.14*	−.05	*+.18*	−.30	*−.47*
									−.45	*−.54*	+.45	*+.45*	+.21	*+.16*	+.35	*+.26*						
Same year	+.01	*−.09*	+.03	*−.18*	−.08	*−.20*	+.14	*+.16*	−.50	*−.63*	−.06	*+.01*	+.63	*+.54*	+.66	*+.52*	+.86	*+.87*	+.60	*+.59*	−.65	*−.59*
									−.58	*−.53*	−.18	*−.20*			+.91	*+.90*						
Following year	+.07	*0*	+.25	*0*	+.25	*0*	+.08	*0*	−.18	*−.16*	−.61	*−.59*	+.32	*+.26*	+.09	*+.13*	+.26	*+.24*	+.26	*+.17*	−.02	*+.06*
									+.20	*+.17*	−.25	*−.18*	+.21	*+.16*	+.12	*+.11*						
Second following year									+.51	*+.28*	−.01	*−.01*	+.05	*+.01*	−.10	*+.01*						
									+.48	*+.33*	+.04	*+.04*	−.36	*−.38*	−.36	*−.35*						
Western winter pork:																						
Third preceding year	+.16	*−.01*	−.16	*−.03*	−.10	*−.03*	+.05	*+.04*														
Second preceding year	+.14	*+.14*	+.33	*+.29*	+.38	*+.32*	−.51	*−.41*	+.14	*+.16*	+.20	*+.24*	−.25	*−.24*	−.22	*−.18*	−.30	*−.34*	−.43	*−.18*	+.27	*+.14*
									+.14	*+.12*	+.29	*+.33*	−.36	*−.35*	−.24	*−.25*						
Preceding year	+.11	*+.13*	+.17	*+.25*	+.26	*+.28*	−.41	*−.35*	−.11	*−.21*	+.83	*+.76*	+.12	*+.01*	+.24	*+.16*	+.18	*+.07*	−.09	*+.14*	−.27	*−.41*
									−.42	*−.48*	+.42	*+.44*	+.12	*+.11*	+.31	*+.21*						
Same year	+.11	*0*	+.17	*0*	+.13	*0*	−.06	*−.01*	−.55	*−.61*	+.15	*+.13*	+.55	*+.45*	+.63	*+.45*	+.79	*+.77*	+.58	*+.56*	−.69	*−.63*
									−.68	*−.59*	+.08	*+.05*	+.91	*+.90*								
Following year	+.17	*0*	+.22	*0*	+.27	*0*	+.06	*0*	−.36	*−.29*	−.58	*−.48*	+.45	*+.38*	+.24	*+.27*	+.40	*+.37*	+.37	*+.28*	−.20	*−.08*
									+.02	*+.03*	−.24	*−.15*	+.35	*+.26*	+.31	*+.21*						
Second following year									+.46	*+.19*	−.13	*−.08*	+.16	*+.07*	−.01	*+.05*						
									+.47	*+.28*	−.01	*+.01*	−.28	*−.27*	−.24	*−.25*						

Table 6.—*The coefficients of correlation which involve western annual pack (year beginning March 1) eastern annual pack (year beginning March 1) and farm price of hogs (January 1) [Each is correlated with the corn variables of two preceding, the same and following year and with the hog variables of the preceding, the same and one or two following years. The summer correlation is given above, the winter below, in those cases in which the year is broken into seasons. The actual correlations are given in roman, the expected in italics]*

Item	Corn: Acreage	Corn: Yield	Corn: Crop	Corn: Farm price, Dec. 1	Hogs: Western (by season): Price	Hogs: Western (by season): Weight	Hogs: Western (by season): Pack	Hogs: Western (by season): Pork	Hogs: Annual pack: Western	Hogs: Annual pack: Eastern	Hogs: Farm price, Jan. 1
Western annual pack:											
Second preceding year	+.14 *+.13*	+.34 *+.26*	+.33 *+.29*	−.45 *−.39*							
Preceding year	+.26 *+.24*	+.42 *+.48*	+.49 *+.54*	−.55 *−.52*	−.20 *−.38*	+.67 *+.68*	+.19 *+.03*	+.29 *+.17*	+.26 *+.17*	+.01 *+.28*	−.36 *−.59*
					−.48 *−.66*	+.52 *+.58*	+.26 *+.24*	+.40 *+.37*			
Same year	+.03 *−.13*	−.14 *−.25*	−.19 *−.28*	+.25 *+.23*	−.59 *−.69*	+.01 *−.05*	+.90 *+.90*	+.91 *+.84*		+.58 *+.64*	−.55 *−.56*
					−.44 *−.45*	−.31 *−.26*	+.86 *+.87*	+.79 *+.77*			
Following year	+.16 *0*	+.18 *0*	+.20 *0*	+.14 *0*	+.03 *−.06*	−.51 *−.53*	+.29 *+.16*	+.06 *+.03*	+.26 *+.17*	+.14 *+.11*	+.09 *+.12*
					+.23 *+.20*	−.10 *−.16*	+.27 *+.14*	+.18 *+.07*			
Second following year					+.50 *+.27*	−.14 *+.01*	+.13 *−.02*	+.02 *−.01*			
					+.49 *+.30*	−.07 *+.05*	−.26 *−.36*	−.30 *−.34*			
Eastern annual pack:											
Second preceding year	−.12 *+.11*	+.23 *+.23*	+.17 *+.25*	−.35 *−.33*							
Preceding year	−.03 *+.19*	+.38 *+.38*	+.30 *+.42*	−.40 *−.49*	−.24 *−.30*	+.59 *+.56*	+.07 *+.02*	+.22 *+.13*	+.14 *+.11*	+.32 *+.16*	−.42 *−.51*
					−.60 *−.59*	+.40 *+.46*	+.26 *+.17*	+.37 *+.28*			
Same year	−.03 +.01	+.08 *+.03*	−.01 *+.03*	+.07 *−.07*	−.70 *−.68*	−.10 *+.04*	+.56 *+.54*	+.56 *+.52*	+.58 *+.64*		−.66 *−.62*
					−.56 *−.54*	−.19 *−.01*	+.60 *+.59*	+.58 *+.56*			
Following year	+.09 *0*	+.21 *0*	+.19 *0*	.00 *0*	−.09 *−.22*	−.46 *−.35*	+.16 *+.30*	−.02 *+.21*	+.01 *+.28*	+.32 *+.16*	+.05 *−.06*
					+.19 *+.03*	+.01 *−.10*	−.05 *+.18*	−.09 *+.14*			
Second following year					+.34 *+.13*	−.02 *−.08*	+.14 *+.07*	+.09 *+.05*			
					+.44 *+.20*	−.15 *+.01*	−.35 *−.19*	−.43 *−.18*			
Farm price, Jan. 1:											
Second preceding year	+.17 *−.10*	−.12 *−.20*	−.06 *−.22*	+.24 *+.27*							
Preceding year	+.04 *−.21*	−.36 *−.42*	−.31 *−.47*	+.55 *+.59*	+.04 *+.12*	−.69 *−.70*	+.21 *+.14*	+.04 *−.01*	+.09 *+.12*	+.05 *−.06*	+.42 *+.32*
					+.56 *+.45*	−.54 *−.57*	−.02 *+.06*	−.20 *−.08*			
Same year	.00 *−.13*	−.17 *−.26*	−.10 *−.29*	+.25 *+.37*	+.77 *+.80*	−.34 *−.36*	−.35 *−.39*	−.50 *−.44*	−.55 *−.56*	−.66 *−.62*	
					+.90 *+.92*	−.05 *−.27*	−.65 *−.59*	−.69 *−.63*			
Following year	−.10 *0*	−.22 *0*	−.23 *0*	+.07 *0*	+.56 *+.56*	+.43 *+.35*	−.40 *−.56*	−.30 *−.46*	−.36 *−.59*	−.42 *−.51*	+.42 *+.32*
					+.15 *+.23*	+.12 *+.13*	−.30 *−.47*	−.27 *−.41*			
Second following year					−.17 *−.07*	+.12 *+.22*	−.27 *−.16*	−.21 *−.11*			
					−.40 *−.25*	+.06 *+.04*	+.25 *+.14*	+.27 *+.14*			

ACREAGE

Variations in acreage (Table 3) show a positive correlation in successive years (+0.36) persisting to a slight extent for two years (+0.14). Aside from this tendency no important correlations with preceding condition are brought out in the present data. The acreage planted in a given year has no relation to the preceding crops (+0.04, +0.01). What relation there is to corn price is negative (−0.22 the second preceding year, −0.10 the preceding year). Thus the acreage is clearly not increased to an appreciable extent because of a scarcity of corn and because of high prices in the preceding year. Slight positive correlations are shown with pork production of the preceding year (+0.27 summer, +0.17 winter), as well as with that of the following year: and corresponding negative correlations are shown with pork prices (−0.29 summer, −0.11 winter).

Apparently a large acreage tends to be planted because a large number of hogs is on hand which must be fed, and a small acreage because of a small number of hogs on hand. Altogether, however, acreage is determined only 5 to 10 per cent by the preceding hog situation. There is about 13 per cent determination by the acreage of the preceding year, leaving more than 75 per cent determination by factors other than the preceding corn and hog situation.

YIELD

The fluctuations in yield (Table 3) are undoubtedly due in the main to the weather, which is not dealt with here as a factor. The correlations between yields in successive years, however, throw light on the important question as to whether there are cycles in yield, determined presumably by cycles in the weather. The present data give no indication of the existence of any such cycle. There is actually a negative correlation between successive yields (−0.15) and also between yields two years apart (−0.15). Any cycle of longer period than four years tends to produce a positive correlation between successive years, unless this is eliminated in fitting a trend to the data. Inspection of Figure 2 shows that a cycle of 40 years may perhaps be eliminated in this way, but no shorter cycle can be affected. Thus the present data indicate that no cycle of less than 40 years can be of more than minor importance in determining yield and crop.

While weather conditions are undoubtedly the most important factors, the average yield in the country as a whole may also be influenced by the distribution of the crop. Thus a relatively large acreage in the Corn Belt, associated with a small acreage elsewhere, will result in a high average yield for the country as a whole even under ordinary weather conditions. The slight positive correlation between acreage and yield (+0.19) possibly indicates that fluctuations in acreage are greater in the high-yielding sections of the country than in the low-yielding sections. Similarly the indications of a positive correlation between yield and pork production of the preceding year (+0.20 summer, +0.22 winter), as well as in that following, indicate that an excess of hogs in the Corn Belt determines the planting of an increased amount of corn in this high-yielding section. None of these factors are of much importance. The yield seems to be determined from 5 to 10 per cent by the preceding hog and corn situation, leaving 90 to 95 per cent determination by outstanding causes, of which the weather is undoubtedly the most important.

INFLUENCES OF REMOTE CAUSES ON CORN CROP

The correlations between the corn crop and preceding conditions (Table 3) are in general of the kind to be expected from the correlations involving acreage and yield. The slight negative correlation between the crops of successive years (−0.20) is of this kind. There are positive correlations with the pork production of the preceding year (+0.28 summer, +0.27 winter) in harmony with the positive correlations shown by both acreage and yield. Altogether, however, the corn crop is not determined more than about 10 per cent by the hog situation and perhaps 4 per cent more by the preceding corn crop. Practically, the corn crop can be treated as an independent variable in its relations to the hog situation of the same and later years.

THE DECEMBER CORN PRICE

The annual fluctuations in the price of corn naturally show a close negative correlation with those of the crop. (Table 3) A big crop means cheap corn, whereas, conversely, a small crop means high-priced corn. The relations to acreage and yield are practically those due to their relation to crop. There is 64 per cent determination by crop, and exactly the same figure for determination by acreage and yield combined.

It might be expected that the price of corn would be affected by the number of hogs on hand to be fed, since hog feeding constitutes the most important variable factor in the demand for corn. Actually, however, the indications of such an effect are not very impressive. The correlation between the December price of corn and the hog pack of the same winter is only +0.14. There are, it is true, fairly important correlations with the live weight (−0.43) and pack (+0.31) of the preceding summer. These are doubtless due to some extent to the effect of an excess of hogs in exhausting the reserves of corn and thus stimulating the price of the coming crop. On the other hand, the fact that there are analogous correlations (with signs reversed of course) between the corn crop and these hog variables (live weight +0.18, pack −0.22) which can not be explained in the above way, indicates that this explanation is not complete. It is probable that these effects are due at least as much to effects of the corn crop on the hog situation as to effects of the hog situation on the corn price. The summer live weight and pack (season ending October 31) precede the December corn price in time, but the latter is representative of the change in corn price which begins as soon as there is knowledge of the size of the crop. A small crop and high-priced corn would tend to cause a premature marketing of light-weight hogs and thus result in correlations of the observed kind.

There is practically no correlation between corn prices of successive years (+0.08) or two years apart (−0.11) and, as we have just seen, there can be only a slight relation to the hog situation in which the latter can be interpreted as the cause. Thus the corn price can be dealt with in relation to the hog situation as an independent variable without any serious error.

INFLUENCE OF CORN ON THE HOG SITUATION

It may be seen in Table 3 that there are important correlations between the corn variables and the hog variables of the same and later years. The more important of these relations are shown graphically

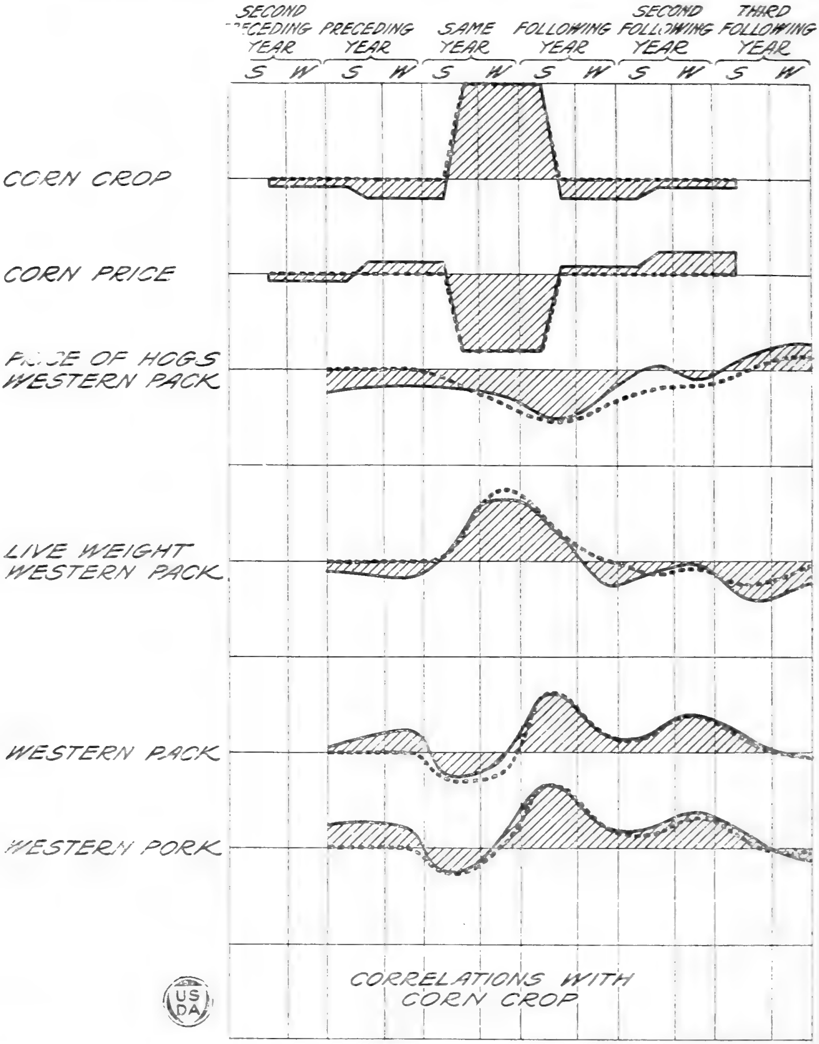

FIG. 16.—The typical variations in corn crop, the price of corn, the price of hogs, the live weight of hogs, and western pack and pork production which precede, accompany, and follow a given corn crop

The summer (S) and winter (W) seasons of six years are represented between the vertical lines, reading from left to right. The summer seasons are represented as longer than the winter seasons. The given corn crop is represented as determining the relative corn supply for about a year following. The variations of all the quantities are assumed to be measured from their respective trends in terms of their average (more accurately, their standard) deviations. They are thus simply the correlations as given in Table 3. The solid lines are the observed correlations, the dotted lines are those expected on the theory advanced in the text and summarized in Figure 27.

in Figures 16 and 17. The correlation can be interpreted as giving the average departure from the trend of one of the variables, in relation to a given departure of the other variable, both departures being measured in terms of their respective average amounts of variation. Figure 16, reading from left to right, represents conditions in six successive years, with each year divided into a longer summer season and a shorter winter season. A unit deviation in the corn crop is represented as occurring in the third summer. The observed relative

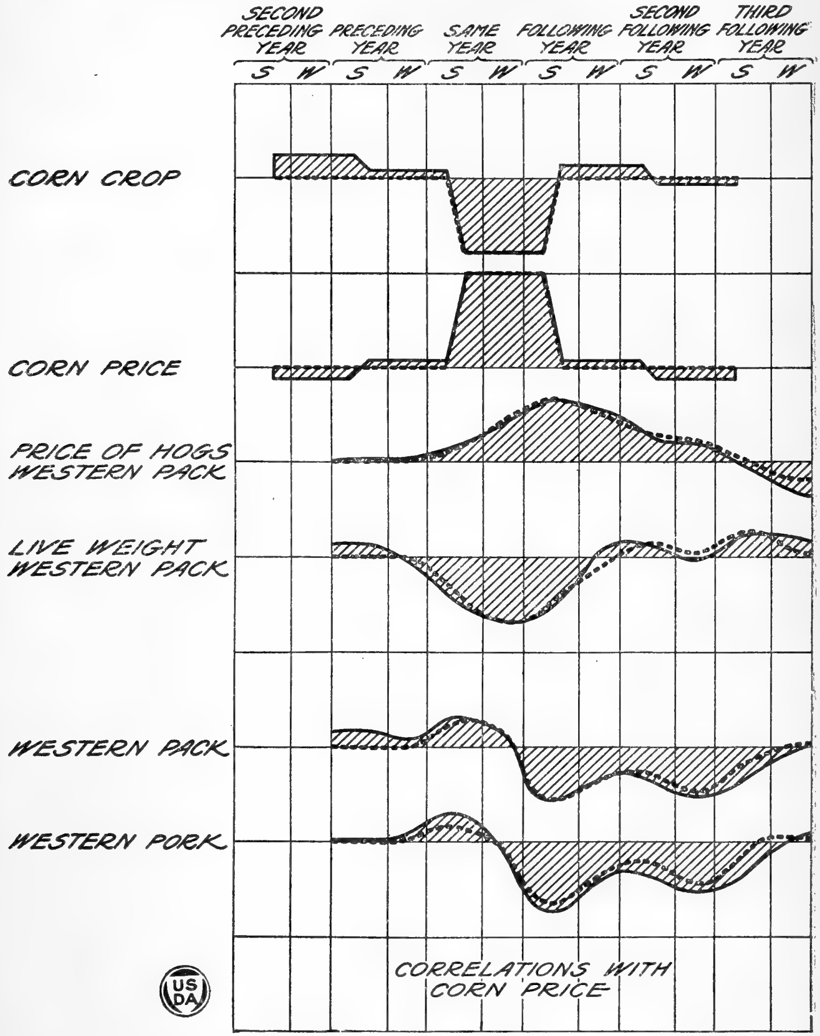

FIG. 17.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the December farm price of corn. The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

average deviations in corn crop in the two preceding and two following years are shown in the top line, and the corresponding relative deviations in corn price in the line below. The corn price deviates 80 per cent in relation to a given corn crop. Figure 17 gives similarly the average deviation of the various quantities in relation to the price of corn. The two sets of figures are in close agreement, taking into account the inverse relation between crop and price. The reader will have little difficulty in forming logical explanations of the larger and more significant deviation in the hog variables relative to the given deviations in corn crop and price. In the summer of a big crop there appears to be a withdrawal from slaughter, which may be for either breeding or later feeding, or because of both causes. In spite of this withdrawal the price of hogs begins to drop, presumably either in sympathy with the drop in corn prices or in expectation of an excess of hogs. Live weights begin to increase. This may be due to either of two causes, an increase in breeding, which withdraws young sows from market, or heavier feeding. Pork production drops in correlation with its major factor, the amount of slaughter.

In the winter following a big crop slaughter and pork production are about average; the price of hogs continues to drop and live weight continues to increase, the latter reaching its maximum.

In the second summer slaughter and pork production reach a maximum. This condition can be due only to a rather small extent to breeding stimulated by the abundance and cheapness of corn. The hogs bred in the previous fall and farrowed in the spring would not come, in the main, on the market until the second winter (season beginning November 1). Early marketing of hogs that would not be marketed until winter, except for the abundance of corn, is doubtless a factor; but the main element in this heavy slaughter must be looked for in the hogs previously withheld. A tendency to concentrate as much of the slaughter as possible in the summer, if the supply of corn warrants, would be brought about by the higher hog prices which prevail in this season as shown in Table 2. It is not surprising to find that the price of hogs reaches its minimum in this second summer (relative to the seasonal average). Live weight begins to fall off.

In the second winter slaughter and pork production have fallen off, though still well above the average. Hog prices begin to rise and live weight becomes about normal.

In the third summer heavy slaughter and pork production continue, though prices become about normal. Live weight tends to reverse its previous rise, falling below normal. The continued heavy slaughter in the second winter and third summer must be due to breeding stimulated by the corn crop. In the third winter a distinct second peak is reached by slaughter and pork production. This must be due to the cumulative effect of heavy breeding. Hog price shows a slight tendency to a second drop, reflecting presumably this secondary rise in slaughter. Live weight continues slightly subnormal.

The fourth summer still shows some effect on slaughter and pork production. Hog prices rise to normal or even above normal, however, and live weight falls well below normal. It is probable that the favorable conditions due to the big crop have stimulated an overproduction of hogs and that a reaction has begun. This reaction manifests itself to a greater extent in the fourth winter in which slaughter and pork production have returned to normal; but price has risen distinctly above normal, presumably in expectation of a shortage. Live weight continues below normal.

All the above-mentioned effects are reversed following a crop below instead of above the average.

Among the other hog variables, total western slaughter shows the correlations with corn crop and price to be expected from the sum of western summer and winter slaughter. Total eastern slaughter shows, for the most part, parallel but smaller correlations. It is to be expected that the corn crop would have less effect on eastern than on western slaughter.

The farm price of hogs taken as of January 1, the exact middle of the winter season (November to February, inclusive) should show correlations approximately the same as those shown by winter price. In fact, there is a close similarity. The farm price, however, seems to lag somewhat behind the packer's cost.

The two factors of corn crop—acreage and yield—show correlations with the hog variables in approximate proportion to their relative influence on fluctuations in the crop. The correlations with yield are thus very close to those of crop itself, whereas those with acreage are much smaller and only the peak effects are clearly brought out.

TABLE 7.—*The percentage to which the hog variables are determined by various factors or combinations of factors*

[The years of the factors are indicated in italics in parentheses, *0* for the same hog-packing year (summer and winter), *1* for the preceding packing year, etc. Compare with the regression formulas of Table 11]

Item	Single corn crop	Single corn price	Single summer weight	Maximum single factor
	Per cent	*Per cent*	*Per cent*	*Per cent*
Summer hog price	22 (*1*)	44 (*1*)	46 (*1*)	58 W. pr. (*1*).
Winter hog price	08 (*1*)	31 (*1*)	40 (*1*)	47 S. pr. (*0*).
Summer live weight	14 (*1*)	26 (*1*)	37 (*2*)	37 S. wt. (*2*).
Winter live weight	40 (*0*)	40 (*0*)	23 (*0*)	40 Crop (*0*).
Summer pack	37 (*1*)	34 (*1*)	23 (*1*)	37 Crop (*1*).
Winter pack	18 (*2*)	28 (*2*)	61 (*1*)	61 S. wt. (*1*).
Summer pork	40 (*1*)	52 (*1*)	28 (*1*)	52 C. pr. (*1*).
Winter pork	15 (*2*)	26 (*2*)	69 (*1*)	69 S. wt. (*1*).
Western pack	24 (*1*)	30 (*1*)	45 (*1*)	45 S. wt. (*1*).
Eastern pack	9 (*1*)	16 (*1*)	35 (*1*)	36 W. pr. (*1*).
Farm price	9 (*1*)	30 (*1*)	48 (*1*)	59 S. pr. (*0*).

Item	Total corn crops	Total corn prices	Corn crops and summer live weight	Miscellaneous
	Per cent	*Per cent*	*Per cent*	*Per cent*
Summer hog price	22 (*1, 2*)	50 (*1, 2*)	69 (*1–1, 2*)	76 Corn pr. (*1*), S. wt. (*1, 2*).
Winter hog price	24 (*0, 1, 2, 3*)	55 (*0, 1, 2, 3*)	67 (*0, 1–0, 1*)	71 Corn pr. (*1, 2*), S. wt. (*1*).
Summer live weight	24 (*1, 2, 3*)	31 (*1, 2, 3*)	47 (*1–2*)	60 Corn pr. (*1*), W. pr. (*1*).
Winter live weight	49 (*0, 1, 2, 3*)	47 (*0, 1, 2, 3*)	55 (*0–0*)	59 Crop (*0*), S. wt. (*0*), S. pack (*0*).
Summer pack	57 (*1, 2, 3*)	57 (*1, 2, 3*)	59 (*1–1, 2*)	
Winter pack	27 (*0, 1, 2*)	37 (*0, 1, 2*)	64 (*1, 2–1*)	67 W. wt. (*1, 2*), S. wt. (*1*).
Summer pork	62 (*1, 2, 3*)	76 (*1, 2, 3*)	61 (*1–1, 2*)	66 Corn pr. (*1*), S. pr. (*2*).
Winter pork	32 (*0, 1, 2*)	41 (*0, 1, 2*)	72 (*1, 2–1*)	71 W. wt. (*1, 2*), S. wt. (*1*).

The degree to which the hog variables are determined by corn crop or price can be found by calculating coefficients of determination (the squares of the coefficients of multiple correlation). Table 7 shows the maximum percentage determination by a single preceding crop or price and the percentage determination by all preceding crops or by all preceding prices, as well as other coefficients which will be discussed later. Summer slaughter and winter weight are determined 57 per cent and 49 per cent, respectively, by preceding crops and practically the same by preceding corn prices. On the other hand, winter slaughter and summer weight are determined only 27 per cent and 24 per cent, respectively, by preceding crop and 37 per cent and 31 per cent by preceding prices. They must be determined largely by factors in the hog situation other than the corn crop. Both summer and winter prices are determined relatively little by the preceding corn crops (22 per cent and 24 per cent, respectively), but are at least half determined by corn prices (50 per cent and 55 per cent). A direct influence of corn price on hog prices is again suggested, but also the influence of fluctuations in the general price level.

THE HOG VARIABLES

The correlations among the hog variables are given in Tables 4, 5, and 6. The more important ones are shown graphically in Figures 18 to 25, which are made according to the same plan as Figures 16 and 17. Each figure shows the deviations which occurred in the various quantities relative to a unit deviation of a given one of them.

Inspection of these figures shows at once that the various factors of the hog situation are closely bound together. It is a considerable problem, however, to disentangle the network of correlations in such way as to give a consistent interpretation of the causal relations.

Pork production, of course, is simply the product of slaughter and dressed weight, the latter of which may be assumed to be a nearly constant proportion of the live weight. In the case of winter pork we find 92 per cent determination by slaughter, 7 per cent by live weight, with 9 per cent to be subtracted because of the negative correlation between the two factors. The sum is 90 per cent, leaving a spurious 10 per cent. In the case of summer pork, there is again 92 per cent determination by slaughter, but 4 per cent determination by weight with 1 per cent to be subtracted because of negative correlation—95 per cent apparent determination, leaving only 5 per cent spurious. In both cases pork is almost wholly determined by slaughter, the percentage fluctuations in weight about its trend being too small to be of much effect (compare Table 2). Live weight is thus of little interest except so far as it gives an indication of the hog situation.

In general, the correlations involving pork production are closely similar to the corresponding ones relating to slaughter, with, however, slight differences which follow live weight. In a few cases involving summer pork there is an apparent discrepancy due to the different periods of time involved. The data for summer slaughter were used, beginning with 1871; while data on summer weight, and hence pork, were available only beginning with 1889.

Total western slaughter is simply the sum of the western summer and the western winter slaughter. The correlations indicate that its fluctuations are determined 35 per cent by the former, 24 per cent by the latter, and 37 per cent jointly, giving a total of 96 per cent. The remaining 4 per cent is spurious.

As already noted, the farm price was found for the very middle of the winter season (January 1). Accordingly it shows a correlation of +0.90 with the price of the western winter pack. The high correlation (+0.77) with the preceding western summer price, with which winter price shows a smaller correlation (+0.69), indicates that farm

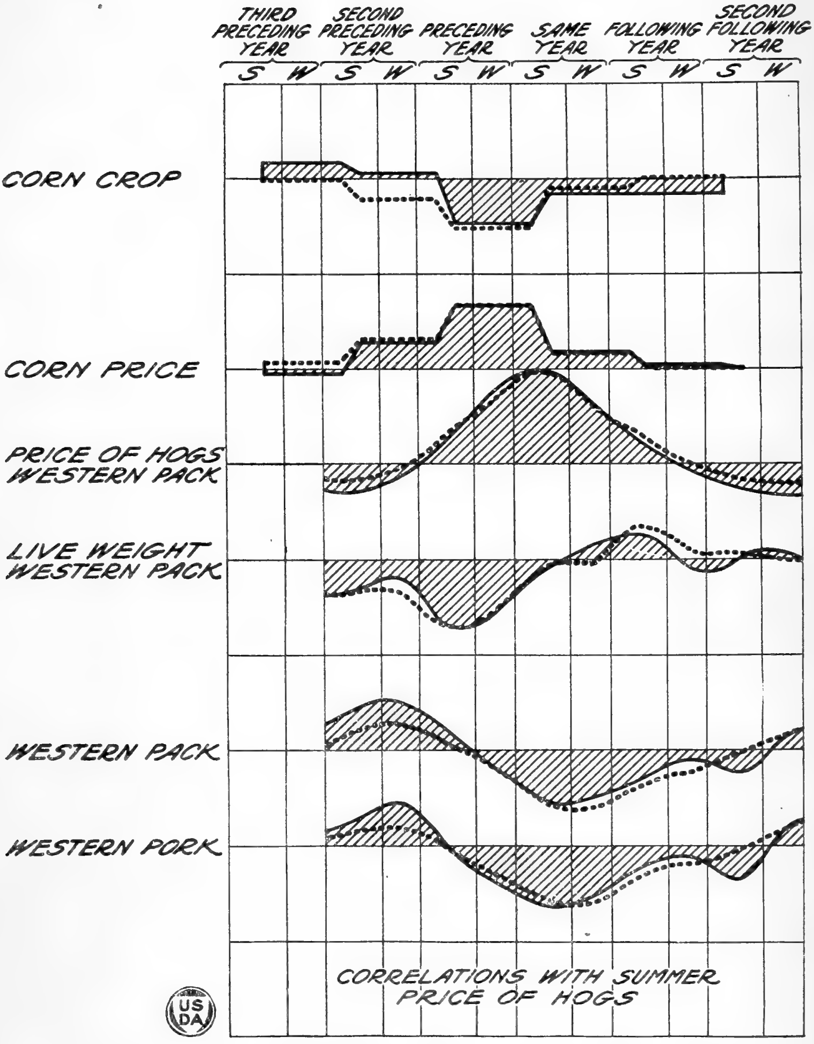

FIG. 18.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the summer price of hogs (western markets). The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

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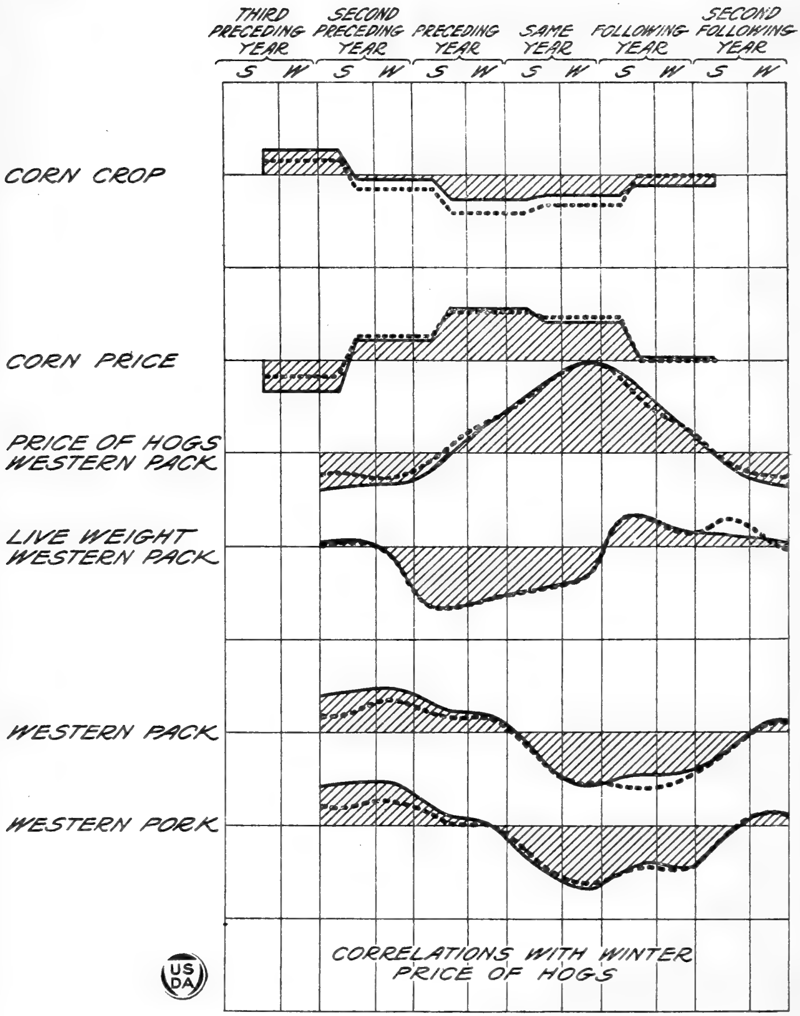

FIG. 19.—The typical variations of the quantities indicated along the left margin in relation to a giveu variation in the winter price of hogs (western markets). The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

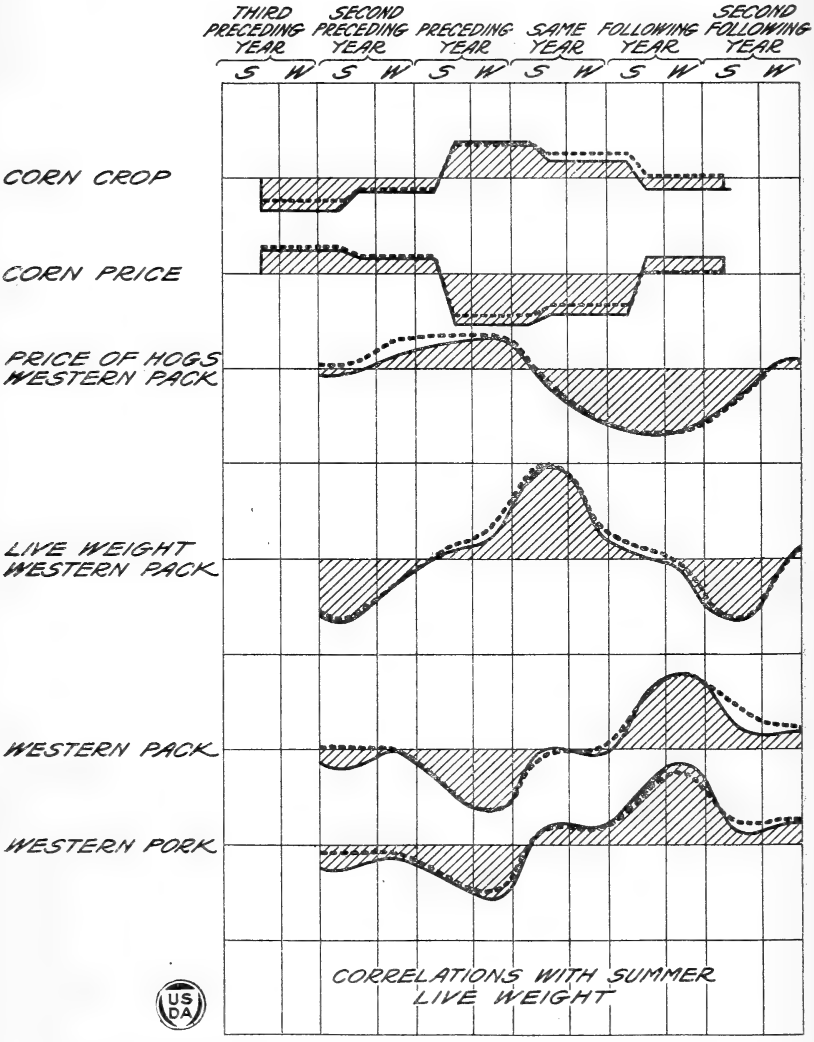

FIG. 20.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the western summer live weight of hogs. The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

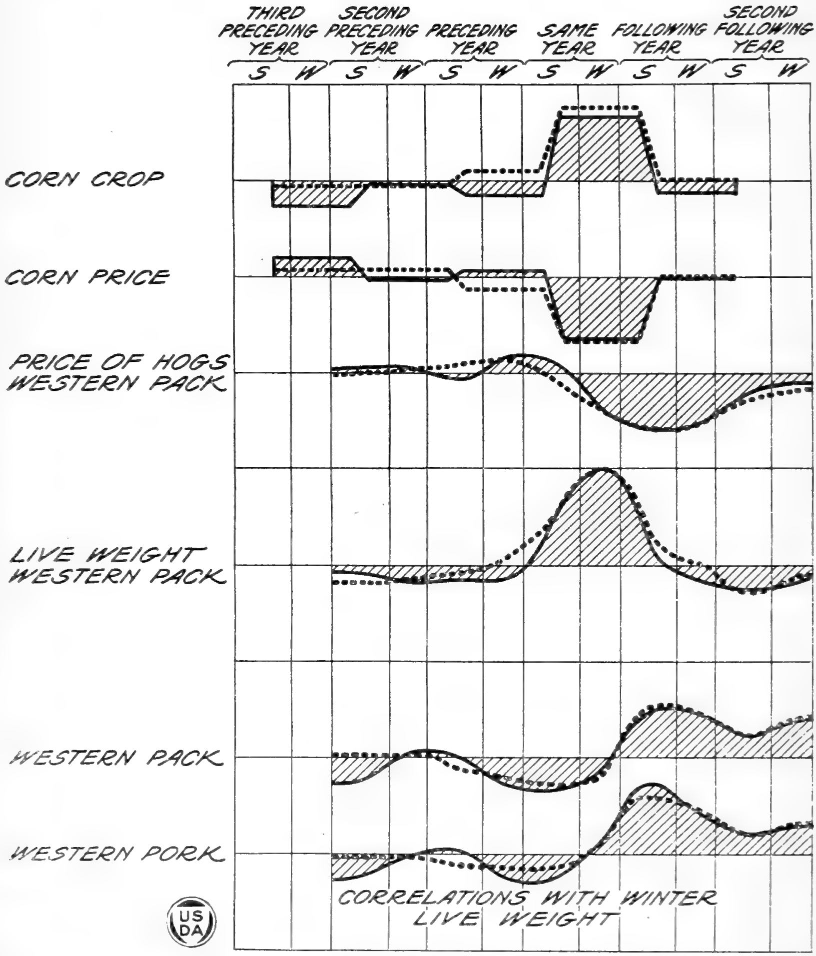

FIG. 21.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the western winter live weight of hogs. The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

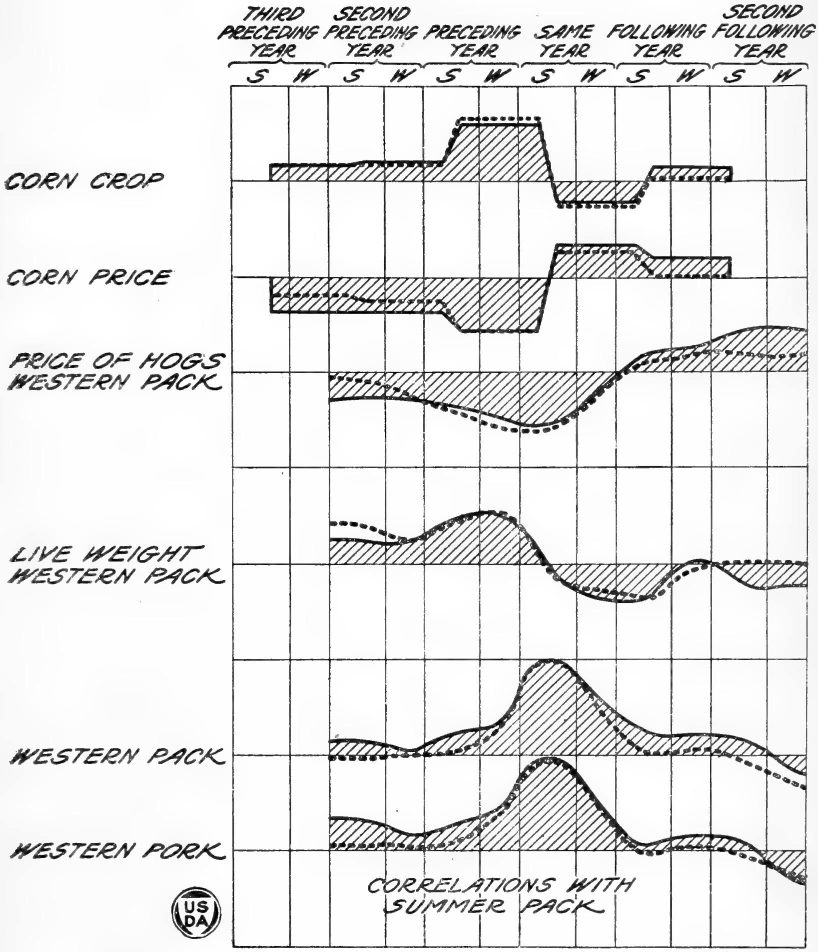

FIG. 22.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the western summer hog pack. The solid lines represent the observed variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

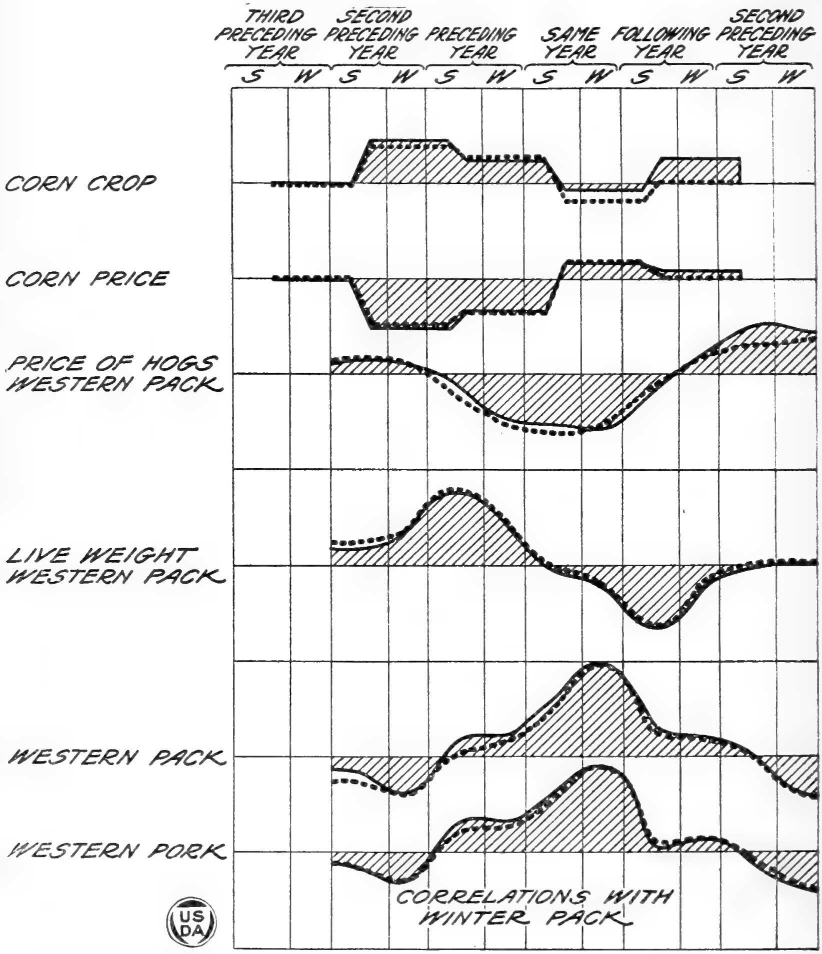

FIG. 23.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the western winter hog pack. The solid lines represent the average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

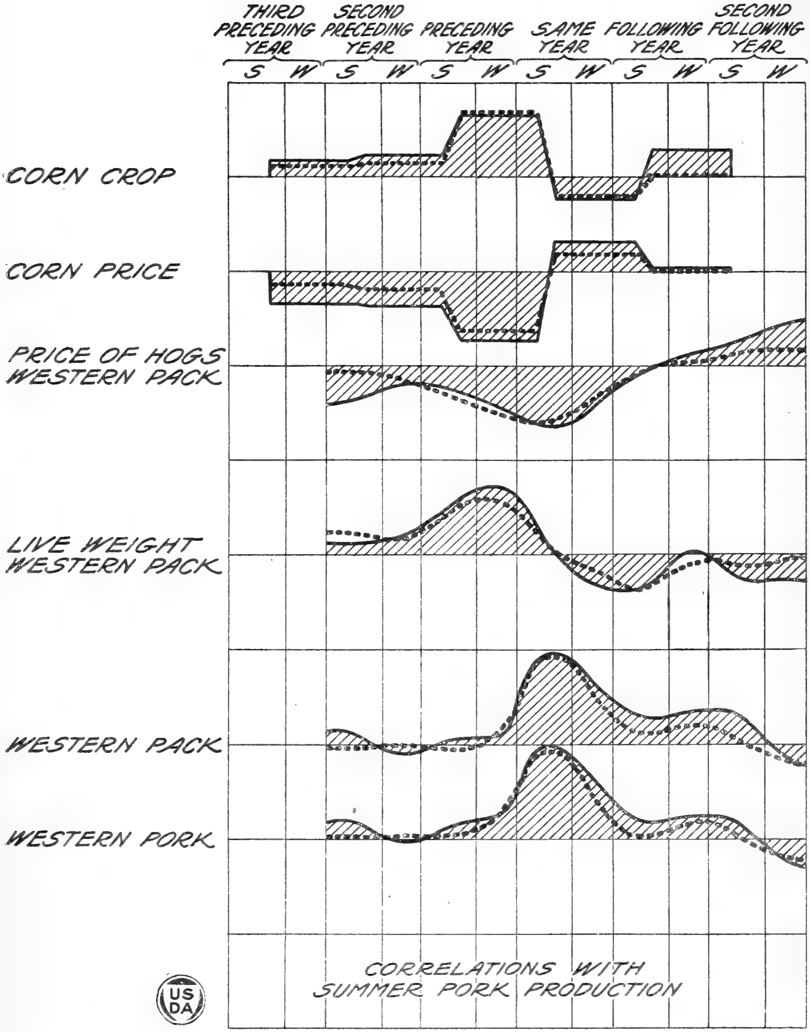

FIG. 24.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the western summer pork production. The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

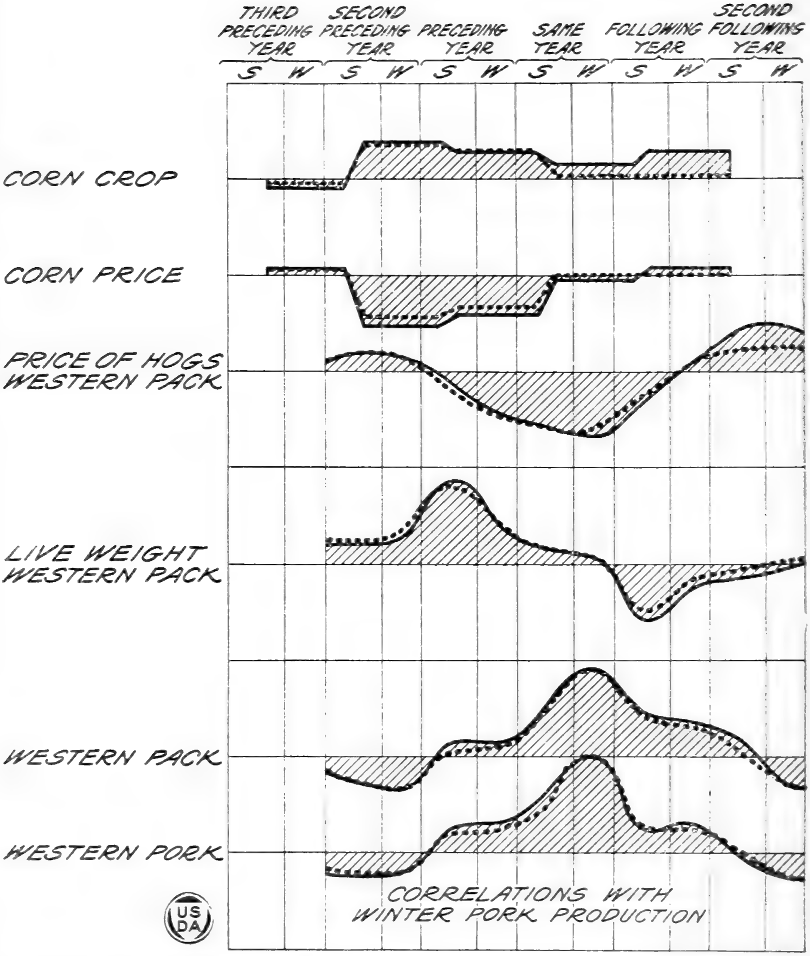

FIG. 25.—The typical variations of the quantities indicated along the left margin in relation to a given variation in the western winter pork production. The solid lines represent the observed average variations (correlations), the dotted lines, those expected according to the theory advanced in the text. The vertical lines separate the longer summer and shorter winter seasons of six years (see legend of fig. 16)

price, as estimated, lags behind winter price. Analysis indicates 50 per cent determination by winter price, 8 per cent by preceding summer price, and 28 per cent joint, a total of 86 per cent determination.

In attempting to analyze the more complex relations, it will be well to limit the discussion at first to the six relatively independent variables dealing with western pack—slaughter, live weight, and price each for summer and winter. Whatever indication they give of factors, other than the corn crop, which affect the hog situation, will first be sought.

TABLE 8.—*The five maximum correlations with preceding variables shown by western summer pack, winter hog price, summer hog price, winter live weight, winter pack, and summer live weight (order of per cent determination by preceding corn prices) in relation to each other and corn crop and corn prices*

(Year indicated in italics in parentheses, as in Table 7)

Item	Per cent determination by corn prices	Five highest correlations				
		1	2	3	4	5
	Per cent					
Summer pack	57	+.61 Corn crop (*1*)	−.58 Corn price (*1*).	+.50 W. weight (*1*)	+.48 S. weight (*1*)	−.45 W. price (*1*).
Winter hog price	55	+.69 S. price (*0*)	−.63 S. weight (*1*).	−.56 W. weight (*1*)	+.56 Corn price (*1*)	−.49 S. weight (*0*).
Summer hog price	50	+.76 W. price (*1*)	−.68 S. weight (*1*).	+.66 Corn price (*1*)	−.58 W. weight (*1*)	+.51 W. pack (*2*).
Winter live weight	47	+.64 Corn crop (*0*)	−.64 Corn price (*0*).	+.48 S. weight (*0*)	−.33 S. pack (*0*)	−.27 Corn crop (*3*).
Winter pack	37	+.78 S. weight (*1*)	+.63 S. pack (*0*).	−.52 Corn price (*2*)	−.50 S. price (*0*)	−.45 W. price (*1*).
Summer live weight	31	−.61 S. weight (*2*)	−.61 W. pack (*1*).	−.51 Corn price (*1*)	−.38 S. pack (*1*)	+.37 Corn crop (*1*).

Some light is thrown on this problem by making a list of the five highest correlations between each of the above-mentioned six variables and a preceding value of one of the others or of the corn crop or price. These correlations are shown in Table 8. The hog variables are arranged according to the extent to which they are determined by preceding corn prices. A rather striking result is brought out. This is the high correlation in each case with a preceding summer weight, the hog variable, which is on the whole most independent of corn prices or crops. Summer weight itself shows its highest correlation with previous conditions in that of −0.61 with the second preceding summer weight. Winter slaughter is the next most independent of corn prices. It shows the remarkably high correlation of +0.78 with the summer weight a year and a half before. Winter weight is more closely correlated with the preceding summer weight than with any other hog variable. The same is true of summer and winter hog prices except that each shows a higher correlation with the immediately preceding price. Finally, summer slaughter shows a high correlation with the preceding summer weight.

Summer weight can be of very little direct importance as a factor, since, as has been shown, it plays only an insignificant direct part in determining even summer pork production. It is evident, however, that it must be a close indicator of some factor, relatively independent of the corn situation, which plays a predominant part with respect to hogs.

SUMMER WEIGHT AND BREEDING

The five highest correlations between summer weight and preceding conditions, as shown in Table 8, indicate that variation in summer weight shows a remarkably strong tendency to reversal after a period of two years (−0.61). Some important factor back of summer weight must tend to oscillate in a 4-year period. The other high correlations show that a heavy summer weight tends to follow a year of light slaughter (summer −0.38, winter −0.61), of cheap corn (−0.51), and to some extent a big corn crop (+0.37).

The first suggestion is that the average weight depends merely on the quantity of corn available in the country and the number of hogs to which it is to be fed. A big corn crop coupled with a light winter slaughter should mean an abundance of corn for summer feeding. There is, however, only 42 per cent determination by this combination of factors. Moreover, the absence of correlation with the slaughter of the summer in question (−0.02) raises doubt as to whether the number of hogs in the country is an important factor.

The fact that the price of corn has a distinctly greater effect than the size of the crop (which is not true in the case of winter weight) indicates that something other than mere quantity of corn is involved. In fact, no combination of preceding factors which does not include the price of corn has been found to give higher than 47 per cent determination. Price of corn and winter slaughter give 55 per cent determination. Still higher is that given by price of corn and winter price of hogs (60 per cent). By taking into account winter slaughter in addition to these two factors the percentage determination is raised to 63, which is the highest figure that has been found. Thus it is not so much the quantity of corn per head of hogs as the ratio of hog to corn prices during the preceding winter that determines summer weight.

The hog-corn price ratio is the factor which measures the profits in hog raising and hence may be expected to have a rather close influence on the amount of breeding. It is probably largely through this effect that it controls summer weight.

Average live weight must, of course, be determined by the type of hog, the average age at slaughter, and the average degree of finish. The last factor should be determined by the ratio of corn supply to the number of hogs, which, as has been shown, is not of first importance. The average age at slaughter depends on a number of things—the type of hog, the market demand, and the number of sows bred. A change in type and in market demand were undoubtedly responsible for the great decline in average live weight between 1870 and 1915. This long-period change, however, was eliminated from consideration by measuring the fluctuations from a falling trend instead of using the absolute live weight. Type and market demand can have little to do with the fluctuations from year to year.

Heavy fall breeding withdraws young sows from the current summer slaughter (season ending October 31) and thus tends to increase the average summer weight. Generally speaking, sows bred in the fall will be slaughtered the next summer after weaning their pigs, when, as relatively old sows, they raise the average summer weight. Heavy spring breeding also tends to increase the average summer weight by withdrawing relatively light sows from slaughter at the beginning of the season and returning some of them at a heavier weight at the end before November 1. Light fall and spring breeding should have the opposite effects.

Thus a heavy summer weight should indicate a period of relatively heavy breeding, beginning the preceding fall and lasting through the following fall, and, conversely, with light summer weight. The correlations indicate that summer weight is determined by the hog-corn price ratio of the preceding winter to a greater extent than by any other combination of preceding factors involved in this study. To complete the argument, it must be supposed that a favorable hog-corn price ratio initiates a period of heavy breeding which lasts through the fall nearly a year after the ratio has begun to fall. In other words, it appears that heavy breeding is determined not so much by the immediate ratio of hog prices to corn prices as to the memory of profits obtained during the past year.

This close relation between summer weight and the relative amount of breeding is brought out even more emphatically by the correlations with following events. The correlation between summer weight and the winter slaughter a year and a half later (+0.78) is one of the closest in the tables. It is confirmed by the even higher correlation of summer weight with the corresponding winter-pork production (+0.83). These correlations require that a heavy (or light) summer weight be accompanied, with great regularity, by heavy (or light) fall breeding. Relatively heavy breeding in the spring and preceding fall is indicated by the wave of slaughter (fig. 20) rising from the low point of the preceding winter to the peak in the second following winter, referred to above (−0.61, −0.02, −0.06, +0.48, +0.78).

The reason why summer weight tends to reverse itself every two years is now apparent. The heavy (or light) breeding of which it is an indicator, reaches its climax nearly a year after the high (or low) hog-corn price ratio which justified it. The result is an overproduction (or underproduction) of hogs, reaching its climax in the second winter and causing a reversal of hog prices and hence in the hog-corn price ratio, in breeding, and thus finally in summer weight. The same "vicious circle" of successive overproduction and underproduction is brought out, though less sharply in winter slaughter and in both summer and winter hog prices.

Probably the cycle is revealed most sharply by summer weight because the latter is of little importance in itself and no forces tend to check extreme fluctuations. Fluctuations in slaughter resulting from those in breeding tend to be smoothed out by the delaying of slaughter at times of surplus and low prices and advance in time of slaughter in times of scarcity and high prices.

Summing up, summer weight is determined primarily by the relative amount of breeding from the preceding through the following fall and secondarily by the amount of finish. Since these two factors are closely related to each other, summer weight is a very close indicator of the amount of breeding. Indirectly it is determined at least 60 per cent by the ratio of hog to corn prices in the preceding winter.

As an indicator of the amount of breeding, it is very closely related to all other phases of the hog situation in the following two or three years. During the years studied, winter-pork production could have been predicted with greater accuracy from knowledge of the summer live weight one and a half years before than from any knowledge of other phases of the hog situation dealt with here, or of corn crop or prices.

The fluctuations in summer weight reveal a marked tendency for hog production to fall into a cycle of overproduction and underproduction, two years from one extreme to the other. The reason appears to be that the peak and low points in breeding come nearly a year after the high or low hog-corn price ratios which warrant them.

WINTER WEIGHT

The correlations involving winter weight are in marked contrast to those involving summer weight. There is little relation between successive seasons. The reason is probably that, whereas fluctuations in summer weight depend largely on the proportion of old and young animals slaughtered, those in winter weight depend primarily on the degree of finish. The winter slaughter is more homogeneous in age than the summer slaughter. It is composed in the main of the large spring-pig crop, but the summer slaughter is composed of odds and ends, the relatively small fall-pig crop, old sows which have weaned their pigs and hogs slaughtered before November or held until after February to take advantage of more favorable prices. The minimum price usually comes in December and the maximum in April or September, with relatively high prices throughout the summer season.

As shown in Table 8 there are only a few correlations of any importance between winter weight and preceding conditions. The high correlations with the preceding corn crop (+0.64) and its price (−0.64) presumably reflect the immediate effect of an abundance (or shortage) of corn on winter feeding. The correlation with the preceding summer weight is probably due largely to the effect of spring breeding on the number of old sows slaughtered in both seasons. Many of the sows bred in the spring would not be slaughtered until after November 1. Finally the negative correlation with the preceding summer slaughter (−0.33) continuing through the winter (−0.18) is due probably to the withdrawal of hogs from slaughter which, as we have seen, is the first effect of a big crop.

Winter weight is determined 40 per cent by either the preceding corn crop or corn price (45 per cent by the two combined). Corn crop, summer weight, and summer slaughter combined determine 59 per cent of its variation. The addition of other factors to this combination only increases it slightly.

Summing up, winter weight is determined primarily by the supply of corn on hand and secondarily by the percentage of old sows in the winter slaughter as a result of heavy breeding the preceding spring.

PRICE OF HOGS

One naturally expects price to show a close negative correlation with supply. There is such a correlation in the case of hogs, but it is not so close as might be expected. It is considerably less close for example than in the case of corn. The correlation between summer-pork production and summer prices is −0.63 and between winter-pork production and winter prices is −0.68. These figures correspond to 40 per cent and 47 per cent determination, respectively. By taking into account the pork production of the preceding season as well as the current production, these figures become 45 per cent and 47 per cent, respectively. By combining the current with the following season, they become 44 per cent and 54 per cent. Thus neither the supply of the past season nor the actual future supply raises the percentage determination to anything approaching completeness.

The price figures apply to exactly the same hogs as the slaughter figures. It is probable, however, that the former are more representative of the average price throughout the country than are the latter in relation to the total slaughter. The curious fact that both western summer and winter prices are more closely correlated with eastern pack than with western (−0.70, −0.56 as compared with −0.59 and −0.44) seems at first to support the view that the relatively low degree of determination of western price by western pork is due to the unrepresentative character of the latter. This is doubtless true to some extent, but in the case of the correlations between western price and eastern pack, another interpretation is more probable. Instead of an important influence of the rather small eastern supply on price, there is probably an influence of price on eastern receipts. Cheap hogs determine heavy eastern shipments and high-priced hogs mean light eastern shipments. Such shipments would have some tendency to reduce the price-supply correlation in the West, but not a very great one because of the relatively small fluctuations in the eastern slaughter.

The highest correlations shown by summer and winter prices are with the price of the preceding season (+0.76, +0.69). These are higher than the correlations for pork production in successive seasons (+0.24, +0.63), which indicates that prices are more stable than supply. Summer price is determined 70 per cent by summer pork and preceding winter price combined. Winter price is determined 61 per cent by winter pork and summer price combined.

Next to preceding prices, the highest correlations with preceding conditions are with summer weight (Table 8). Summer price is correlated −0.68 with the preceding summer weight. Winter price is correlated −0.63 with the second preceding summer weight. These correlations doubtless indicate largely the relation between price and supply, summer weight being, as previously noted, an indicator of the amount of breeding. They are of about the same magnitude as the correlations with current pork production.

The correlations between hog price and corn crop are not very high (maximum −0.47 summer, −0.29 winter). Summer price is determined only 22 per cent by the preceding corn crop and not appreciably more by all previous crops taken together. Winter price is determined only 8 per cent by the preceding, 17 per cent by the two preceding, and 24 per cent by the four preceding crops. The correlations with corn price, however, are much higher (maximum of +0.66 summer and +0.56 winter). Summer price is determined 50 per cent and winter price 55 per cent by preceding corn prices.

Thus the price of corn, the chief factor in the cost of production of hogs, plays as great a part in determining the bids made by the packers for the hogs as does the supply.

The highest degrees of determination by preceding conditions are obtained by taking into account both summer weights and corn prices. Summer price is determined 76 per cent by the price of corn for the preceding year combined with the two preceding summer weights. Winter price is determined 71 per cent by the two preceding corn prices combined with the second preceding summer weight. Roughly speaking, the price paid for hogs by the packers is determined somewhat more than one-third by the price of the corn on which the hogs were raised and fattened, a little more by the supply of hogs, and about one-fourth by unknown factors which would include fluctuations in the demand for pork products.

As already indicated, the correlations of hog price with preceding corn prices and summer weights are much too high to be explained through the mediation of the number and weight of the hogs actually bought by the packers. In the long run, the price of hogs is based more on the total supply of hogs in the country and on the profits of hog raising as affected by corn prices than on the actual market receipts. This probably means that the packer's demand is based to a large extent on current and prospective general conditions; also that there is a prompt reaction (positive) of hog prices on market shipments, which tends to reduce the negative correlations between pack and price.

SUMMER SLAUGHTER

The size of the preceding corn crop is the most important single factor in determining summer slaughter (Table 8, fig. 22). The correlation of +0.61 means 37 per cent determination. The high correlation with the live weight of the preceding winter (+0.50) is in the main due to the common influence of the corn crop. To some extent, however, it should be due to heavy breeding in the spring a year before, which should have a direct influence on the given summer slaughter and, as we have seen, has an important influence on winter weight.

Incidentally, summer pork production shows a much higher correlation with the preceding winter weight (+0.72). This would not be consistent with the correlation of +0.50 were they taken over the same period of years. The years 1871 to 1915 were used for slaughter and 1889 to 1915 for pork production. This discrepancy is not due to a greater influence of corn crop in the later years (correlations +0.60 for slaughter, and +0.64 for pork). It may be due to increasing spring breeding.

The correlation between summer slaughter and the live weight of the preceding summer (+0.48) is a consequence of the common influence of heavy (or light) breeding on the two variables.

The high correlation with the preceding corn crop (+0.61) offers some difficulties. Breeding in the preceding fall, based on the size of the corn crop, would determine a large spring-pig crop but the greater part of these pigs would not be ready for slaughter until after October 31. The abundance of corn left over from a big crop, however, would permit early fattening and marketing, which would allow advantage to be taken of the relatively high summer prices. The relatively low correlation between corn crop and slaughter of the second winter (+0.21) strengthens the conclusion that the early marketing of hogs bred with knowledge of the preceding corn crop is an appreciable factor in determining the summer slaughter. The main influence of corn crop on the following summer's slaughter must, however, be through an effect on the time of slaughter of hogs, already bred when the size of the crop became known. The prevailing high prices of summer hogs would furnish a motive for withholding hogs from slaughter in the preceding winter as well as advancing the time of marketing from the following winter, if the supply of corn permits.

Heavy breeding made with knowledge of the corn crop would increase the next summer slaughter through the sows slaughtered after weaning their spring pigs. In harmony with this condition, heavy breeding during the given summer should tend to reduce slaughter. Indications of such an effect were seen in negative correlations between summer slaughter and corn crop and price of the same year.

The factors discussed so far go back no farther than one year. The correlations with live weight, slaughter, and price in preceding years indicate, however, that heavy breeding for several years past tends to increase summer slaughter. Although relatively few hogs produced by breeding more than a year and a half before would enter into the summer slaughter, heavy breeding before this could have an effect by causing such a surplus in preceding years that hogs would be held to a greater age, thus shoving the surplus into the next season with a continuation of the high age of slaughter.

Summing up, summer slaughter is determined primarily by various effects of the preceding corn crop, including slaughter held back from the previous winter and advanced from the following winter to avoid low winter prices and made possible only by abundance of corn, heavy breeding in the preceding fall resulting in an excess of sows, and some early marketed spring pigs. Heavy breeding even as far back as the third preceding year results in a surplus of hogs, shoved on from year to year by delayed marketing, thus increasing slaughter in the summer in question. A big corn crop in the same summer has some tendency to reduce slaughter probably both from sows withheld for breeding and from pigs withheld for fattening with the new corn.

The preceding corn crop by itself determines 37 per cent of the variation in summer slaughter. The three preceding corn crops or corn prices determine 57 per cent. The highest percentage determination by three factors was that by preceding corn crop and the two preceding summer weights (59 per cent).

WINTER SLAUGHTER

The winter slaughter is largely composed of the preceding spring-pig crop and hence is determined largely by the amount of breeding in the second preceding fall. The outstanding correlation is that with summer live weight a year and a half before (+0.78), which, as we have seen, is an indicator of the amount of breeding. The existence of some correlation with the summer weight two and a half years before (+0.19) indicates that heavy breeding 2 or even 3 years before has an effect explainable on the same basis as with summer slaughter.

The corn crop has relatively little influence on winter slaughter. In the winter following an exceptional crop the correlation is negative so far as it goes (−0.08). In the second winter it is only slightly positive (+0.21) in spite of the heavy fall breeding determined by a big crop or the light fall breeding by a small crop. As we have just seen, heavy breeding due directly to a big crop tends to swell the following summer slaughter at the expense of the second as well as following winter slaughter. It is not until the third winter after an exceptional crop that there is an appreciable correlation with winter slaughter (+0.42). A large crop stimulates heavy breeding for at least a year and the second large pig crop which results is raised in a season of scarce rather than abundant corn, and hence fattening and slaughter must be delayed into the winter season. There is 18 per cent determination by the third preceding corn crop and only 27 per cent by all three preceding corn crops combined.

In contrast is the 61 per cent determination by the second preceding summer weight, due to the correlation of +0.78 referred to above. The combination of this with the second and third preceding corn crops increases the coefficient of determination to only 64 per cent. The highest coefficient which has been found is from the combination of the second preceding summer weight with the two preceding winter weights (67 per cent).

The negative correlation (−0.36) with the winter slaughter two years before or later, has already been noted as a manifestation of the cycle in hog production discussed under summer weight.

Summing up, winter slaughter is determined largely by the amount of breeding in the second preceding fall. Breeding before this time has an appreciable effect. The immediate effect of the corn crop is slightly negative, since an abundance of corn tends to concentrate slaughter in the summer at the expense of the winter season.

THE SYSTEM OF HOG AND CORN VARIABLES AS A WHOLE

From the foregoing discussion it will be seen that most of the correlations among the hog and corn variables can readily be accounted for even though they may not agree in all cases with what might seem most probable beforehand. In many cases, indeed, there seems to be a superfluity of reasonable explanations, Only too often, however, it turns out that what seems to be the obvious explanation in the case of one correlation is wholly incompatible with what seems the equally obvious explanation in another case.

In the complex network of interrelations, satisfactory analysis of the system requires that the consequences of each hypothetical relation of cause and effect be worked out with respect to every one of the 510 observed correlations. Such an analysis must be as rigidly quantitative as the data permit.

This may appear to be a hopeless task, in such a system as the present, in which the number of possible actions and reactions among the variables would seem almost infinite. Nevertheless, by testing the consequences of different reasonable hypotheses as to causal relations by the method of path coefficients [6] and choosing that which

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[6] Wright, Sewall, 1921. Correlation and Causation. *In* Jour. Agr. Research, v. 20, No. 7, pp. 557-585.

best fits the observed facts, an approach can be made to a quantitative solution, which, it is believed, gives a better grasp of the situation as a whole, as well as in detail, than can be obtained from any mere discussion of the correlations.

THE METHOD OF PATH COEFFICIENTS

The first step in the use of this method is the construction of a diagram in which the supposed causal relations among the variables are represented by arrows. Each correlation can be represented symbolically as the resultant of the paths of influence leading from one variable to the other or to both from a common cause. This gives as many simultaneous equations as there are correlations, 510 in the present case, for the solution of the path coefficients. Additional equations are furnished in those cases, such as the determination of corn crop by acreage and yield, in which it is known that one variable is completely determined by two or more of the others. In the present case it would be theoretically possible to find coefficients for more than 510 different paths of influence. This number doubtless would not be too many for a complete solution. It would be hopeless, however, to deal with so large a number of unknown quantities, and even if it were practicable the use of so complicated a system would defeat the purpose of the analysis, the object of which is to obtain as accurate an explanation of the correlations as possible with a minimum complexity in the causal relations. The problem then resolves itself into the discovery of a simple system of relations, which shall give a reasonably close approximation to the 510 correlations.

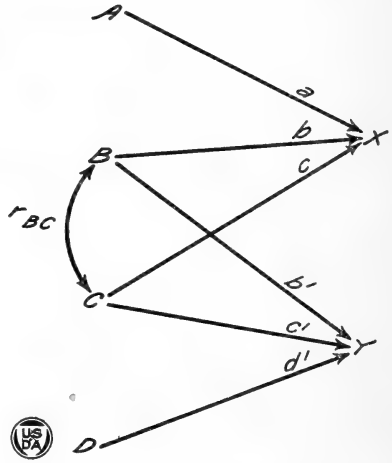

FIG. 26.—A diagram illustrating the path coefficients in the case of two variables (X and Y), determined in part by correlated common causes (B and C)

A path coefficient, measuring the importance of a given path of influence from cause to effect, is defined as the ratio of the standard deviation of the effect, when all causes are constant except the one in question, the variability of which is kept unchanged, to the total standard deviation of the effect. Figure 26 represents a system in which the variations of two quantities X and Y are determined in part by independent causes represented by A and D, and in part by common causes, represented by B and C. These common causes may be correlated with each other through more remote causes, which are not represented in the figure but whose resultant is the correlation coefficient, r_{BC}. It is assumed that all the relations are linear. In practice, slight departures from linearity do not invalidate the analysis. Combination of effects by multiplication, as in the relations of acreage and yield to crop, or slaughter and weight to pork production, are sufficiently close to being additive where the variability of the quantities is small in comparison with their mean values.

It can be shown that the squares of the path coefficients measure the degree of determination by each cause. If the causes are independent of each other and all are accounted for, the sum of the squared path coefficients is unity. If the causes are correlated, terms representing joint determination must be recognized. The complete determination of X in Figure 1 by factors A, B, and C can be expressed by the equation

$$(1) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad a^2+b^2+c^2+2bc\, r_{BC}=1$$

where a, b, and c are the coefficients for the paths indicated in the diagram.

The squared path coefficients and the expressions for joint determination measure the portion of the squared standard deviation due to the causes singly and jointly, respectively.

The correlations between two variables can be shown to equal the sum of the products of the path coefficients along all the paths by which the variables are connected. In Figure 1, X and Y are connected by 4 paths $X–B–Y$, $X–C–Y$, $X–B–C–Y$, and $X–C–B–Y$. Taking the products of the path coefficients and the correlations (which represent the resultant of path coefficients) along each of these paths and adding, we have

$$(2) \quad . \quad . \quad . \quad . \quad . \quad . \quad r_{XY}=bb'+cc'+br_{BC}c'+cr_{BC}b'$$

Equations 1 and 2 can be expressed more compactly in the following forms obtained by application of equation 2 itself.

$$(1a) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad ar_{AX}+br_{BX}+cr_{CX}=1$$

$$(2a) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad r_{XY}=br_{BY}+cr_{CY}$$

The method of analysis to be used here consists in equating each observed correlation to the system of path coefficients responsible for it, as in Equation 2, or in expressing complete determination of one variable by others, as in Equation 1.

CENTRAL SYSTEM OF RELATIONS

It would be hopeless to attempt to deal with all the variables at once at the outset. Those which are most fundamental should be dealt with first in a central system; those with least causal influence on the others being ultimately related to this system peripherally.

Among the corn variables, the price has in general the closest correlations with the hog variables and is thus the best one to take as representative of the influence of corn on hogs, although the most dependent variable within the corn system itself.

The most fundamental factor in the hog situation is the amount of breeding. There are no calculated correlations between breeding and the other quantities, but evidence has been found that summer weight is a close indicator of the amount of breeding in the same year, although also influenced by the breeding in the preceding fall and perhaps to some extent by the amount of corn in relation to the number of hogs. Of course the winter slaughter a year and a half later is also, to a considerable extent, an indicator of the amount of breeding.

It will be recalled that summer weight was determined 60 per cent by the preceding winter price of hogs (positive) combined with the price of corn (negative) at the same time, and that this was a higher percentage determination than by any other combination not involving these two factors. This result was interpreted as meaning that the amount of breeding is determined primarily by the memory of profits derived from hog raising during the preceding year. This conclusion is supported to some extent by the correlations of winter slaughter with price of hogs (+0.11) and corn price (−0.52) of two years before. Winter price of hogs must therefore be taken into the central system of relations.

This price itself is determined to the greatest extent by a preceding summer weight (indicating breeding) and preceding prices of corn. Thus a system of hog-corn relations can be built around the relations between breeding (as indicated by summer weight), winter price of hogs, and corn price. In fact, a fairly satisfactory central system

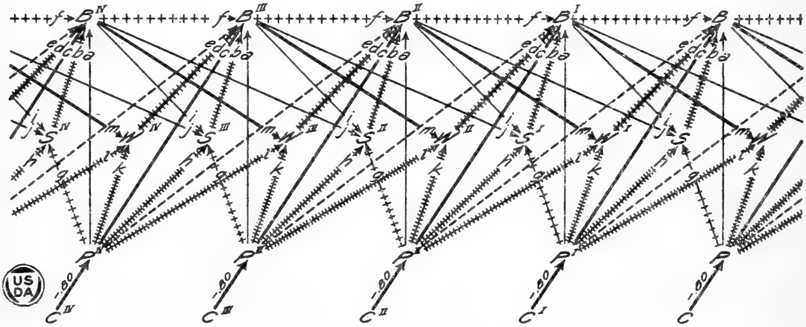

FIG. 27.—A diagram illustrating the system of interactions between corn crop (C), corn price (P), the summer price of hogs (S), the winter price of hogs (W), and the amount of hog breeding (B) in successive years, which has been found to be most successful in explaining the observed correlations. The negative paths of influence are represented by plain arrows, the positive, by crosshatched arrows. The most important paths ($c=-.85$, $d=+.65$, $m=-.65$, $p_{po}=-.80$) are represented by heavy lines, the least important ones ($e=-.15$, $f=+.10$, $g=+.15$) by broken lines, and the paths of intermediate importance ($a=-.45$, $b=+.35$, $h=+.50$, $i=-.40$, $j=-.40$, $k=+.45$, $l=+.25$) by light lines

can be constructed around these three variables. It is improved by taking into account also the summer price of hogs.

There are many possible paths of influence among these four variables. A great many have been tested. The following system (fig. 27) has given the most satisfactory results and no system differing from it to an important extent has been at all successful. The corn crops (C) and prices (P), summer and winter hog prices (S, W), and the hypothetical factor, breeding (B), are shown for five successive years. The paths representing the influence of variables on each other are indicated by connecting lines, with arrows indicating the direction of influence. The positive effects are indicated by crossed lines, the negative by uncrossed lines.

For the reasons previously discussed, the corn crop is represented as a wholly independent variable, unaffected by the hog situation or even by the corn crops of the preceding year. Corn price is represented as affected only by the crop.

Summer hog price is represented as influenced by four factors—the breeding of the two preceding years (negative effects) and the corn prices of the same and preceding falls (positive effects). The interpretation is that the packers' demand is based on their judgment of the scarcity of hogs in the country (low past breeding) and of the prospective hog supply, as influenced by corn prices. The actual marketing of hogs is probably to some extent responsible for these correlations as an intermediary factor between breeding and hog price and possible also between corn price and hog price. A hog price which does not permit a profit, owing to the price of corn, tends to cause a drop in shipments to market.

Winter hog price is similarly represented as influenced by the breeding of the second preceding year (negative) and the prices of the two preceding fall corn crops (positive).

The amount of breeding (most of which occurs late in the fall) is represented as determined largely by the factors which determine the profits from hog raising during the summer and preceding winter, namely, the summer and winter hog prices (positive) and the price of the two preceding corn crops—those on which the hogs were raised and fattened—(negative). The price of the current crop (also negative) and the amount of breeding of the preceding year (positive) are also represented as factors. Cheap corn stimulates fall breeding. The correlation between successive years can be interpreted as due to a tendency among breeders to stay in the business.

While the diagram of relations may appear somewhat complex, only 14 paths of influence are represented—1 back of corn price, 4 back of summer hog price, 3 back of winter hog price, and 6 back of breeding. Using the letters indicated in the diagram for the 13 corresponding unknown path coefficients (the coefficient for the path corn crop to corn price, is simply the correlation −0.80), the following equations can be formed. (Table 9.) The correlations with summer weight and second following winter slaughter are given in parentheses as indicators of the correlations involving breeding. In both cases, it must be remembered, the breeding of the preceding year is also considered to be a factor.

Table 9.—*The equations expressing the correlations within the central system of variables, corn price (P), summer hog price (S), winter hog price (W), and hog breeding (B) as the resultant of path coefficients*

[Actual correlations are given in the second column, breeding being represented in parentheses by summer weight of the same year and winter pack of the following year. The calculated correlations are given in the last column]

			Calculated value
r_{SP}	$=+0.18$	$=g$	+0.15
r_{BP}	$=(-0.43, -0.32)$	$=a+br_{SP}$	−0.40
r_{WP}	$=+0.40$	$=k$	+0.45
$r_{SP^{I}}$	$=+0.66$	$=h+ir_{BP}$	+0.66
$r_{BP^{I}}$	$=(-0.51, -0.53)$	$=br_{SP^{I}}+c+dr_{WP}+fr_{BP}$	−0.37
$r_{WP^{I}}$	$=+0.56$	$=l+mr_{BP}$	+0.51
$r_{SP^{II}}$	$=+0.29$	$=ir_{BP^{I}}+jr_{BP}$	+0.31
$r_{BP^{II}}$	$=(+0.13, -0.01)$	$=br_{SP^{II}}+dr_{WP^{I}}+e+fr_{BP^{I}}$	+0.25
$r_{WP^{II}}$	$=+0.20$	$=mr_{BP^{I}}$	+0.24
$r_{SP^{III}}$	$=-0.04$	$=ir_{BP^{II}}+jr_{BP^{I}}$	+0.05
$r_{BP^{III}}$	$=(+0.22)$ --	$=br_{SP^{III}}+dr_{WP^{II}}+fr_{BP^{II}}$	+0.20
$r_{WP^{III}}$	$=-0.31$	$=mr_{BP^{II}}$	−0.16
$r_{SP^{IV}}$	= --	$=ir_{BP^{III}}+jr_{BP^{II}}$	−0.18
$r_{BP^{IV}}$	= --	$=br_{SP^{IV}}+dr_{WP^{III}}+fr_{BP^{III}}$	−0.15
$r_{WP^{IV}}$	= --	$=mr_{BP^{III}}$	−0.13
$r_{BB^{I}}$	$=(+0.05, +0.21)$	$=[r_{BP^{I}}(dl+e)+r_{BP}(bh+c+dk)+bi+f]/[1-bj-dm]$	+0.07
$r_{SP^{I}}$	$=(-0.68, -0.50)$	$=hr_{BP}+i+jr_{BB^{I}}$	−0.63

Table 9.—*The equations expressing the correlations within the central system of variables, corn price (P), summer hog price (S), winter hog price (W), and hog breeding (B) as the resultant of path coefficients*)—Continued

[Actual correlations are given in the second column, breeding being represented in parentheses by summer weight of the same year and winter pack of the following year. The calculated correlations are given in the last column]

			Calculated value
r_{WB}	=(−0.49, −0.45)	$=kr_{BP}+lr_{BP^{I}}+mr_{BB^{I}}$	−0.32
$r_{WB^{I}}$	=(−0.63, −0.58)	$=lr_{BP}+m$	−0.75
$r_{SP^{II}}$	=(−0.31, −0.18)	$=ir_{BB^{I}}+j$	−0.43
$r_{WB^{II}}$	=(+0.07, +0.20)	$=mr_{BB^{I}}$	−0.05
$r_{BB^{II}}$	=(−0.61, −0.36)	$=br_{SB^{II}}+dr_{WB^{I}}+er_{BP}+fr_{BB^{I}}$	−0.57
$r_{SB^{III}}$	=(-- , +0.51)	$=ir_{BB^{II}}+jr_{BB^{I}}$	+0.20
$r_{WB^{III}}$	=(-- , +0.48)	$=mr_{BB^{II}}$	+0.37
$r_{BB^{III}}$	=(-- , −0.01)	$=br_{SB^{III}}+dr_{WB^{II}}+fr_{BB^{II}}$	−0.02
$r_{SB^{IV}}$	=--	$=ir_{BB^{III}}+jr_{BB^{II}}$	+0.23
$r_{WB^{IV}}$	=--	$=mr_{BB^{III}}$	+0.01
$r_{BB^{IV}}$	=--	$=br_{SB^{IV}}+dr_{WB^{III}}+fr_{BB^{III}}$	+0.32
$r_{SB^{V}}$	=--	$=ir_{BB^{IV}}+jr_{BB^{III}}$	−0.12
$r_{WB^{V}}$	=--	$=mr_{BB^{IV}}$	−0.21
$r_{BB^{V}}$	=--	$=br_{SB^{V}}+dr_{WB^{IV}}+fr_{BB^{IV}}$	0.00
$r_{SB^{VI}}$	=--	$=ir_{BB^{V}}+jr_{BB^{IV}}$	−0.13
$r_{WB^{VI}}$	=--	$=mr_{BB^{V}}$	0.00
$r_{BB^{VI}}$	=--	$=br_{SB^{VI}}+dr_{WB^{V}}+fr_{BB^{V}}$	−0.18
r_{WS}	=+0.69	$=kr_{SP}+lr_{SP^{I}}+mr_{SB^{I}}$	+0.64
$r_{SW^{I}}$	=+0.76	$=hr_{WP}+ir_{WB}+jr_{WB^{I}}$	+0.65
$r_{WW^{I}}$	=+0.36	$=lr_{WP}+mr_{WB}$	+0.32
r_{BS}	=(−0.12, −0.08)	$=ar_{SP}+b+cr_{SP^{I}}+dr_{SW^{I}}+er_{SP^{II}}+fr_{SB^{I}}$	+0.04
$r_{BW^{I}}$	=(+0.33, +0.11)	$=br_{SW^{I}}+cr_{WP}+d+er_{WP^{I}}+fr_{WB}$	+0.39
$r_{SS^{I}}$	=+0.24	$=hr_{SP}+ir_{BS}+jr_{SB^{I}}$	+0.31
$r_{WS^{I}}$	=−0.09	$=lr_{SP}+mr_{BS}$	+0.01
$r_{SW^{II}}$	=−0.11	$=ir_{BW^{I}}+jr_{WB}$	−0.03
$r_{WW^{II}}$	=−0.32	$=mr_{BW^{I}}$	−0.25
$r_{BS^{I}}$	=(+0.24, +0.11)	$=br_{SS^{I}}+cr_{SP}+dr_{WS}+er_{SP^{I}}+fr_{BS}$	+0.30
$r_{BW^{II}}$	=(+0.13, --)	$=br_{SW^{I}}+dr_{WW^{I}}+er_{WP}+fr_{BW^{I}}$	+0.17
$r_{SS^{II}}$	=−0.26	$=ir_{BS^{I}}+jr_{BS}$	−0.14
$r_{WS^{II}}$	=−0.34	$=mr_{BS^{I}}$	−0.20
$r_{SW^{III}}$	=--	$=ir_{BW^{II}}+jr_{BW^{I}}$	−0.22
$r_{WW^{III}}$	=--	$=mr_{BW^{II}}$	−0.11
$r_{BS^{II}}$	=(−0.04, --)	$=br_{SS^{II}}+dr_{WS^{I}}+er_{SP}+fr_{BS^{I}}$	−0.05
$r_{BW^{III}}$	=--	$=br_{SW^{III}}+dr_{WW^{II}}+fr_{BW^{II}}$	−0.22

Having obtained those equations, approximate solutions for the 13 variables were found by repeated trial. In view of the impossibility of fitting all the equations exactly, as well as the rather high probable errors of the correlations, the path coefficients were solved only to the nearest multiple of 0.05. The following are the results (Table 10) using primes to represent preceding years as in the diagram.

Table 10.—*The central system of path coefficients*

Hog breeding (B)

a (Corn price)	−0.45	*b* (Summer price)	+0.35
c (Corn price′)	−0.85	*d* (Winter price′)	+0.65
e (Corn price″)	−0.15	*f* (Breeding′)	+0.10

Summer price (S)

g (Corn price)	+0.15	*i* (Breeding′)	−0.40
h (Corn price′)	+0.50	*j* (Breeding″)	−0.40

Winter price (W)

k (Corn price)	+0.45	*m* (Breeding′)	−0.65
l (Corn price′)	+0.25		

The correlations which result from these path coefficients are given in the last column in Table 9. In the diagram (fig. 27) the positive paths are marked with crosses. The three highest coefficients (*c*, *d*, *m*) are shown in heavy lines and the three lowest (*e*, *f*, *g*) are shown in dotted lines. With these considerations in mind, the influence of corn on the hog situation and the tendency toward reversal in the amount of breeding every two years are clearly brought out.

Calculating the coefficients of determination, it is found that breeding is determined 73 per cent by the factors represented, leaving 27 per cent residual; summer price is determined 77 per cent, leaving 23 per cent residual; and winter price 82 per cent, leaving 18 per cent residual. It will be recalled that in the four cases in which there was known to be complete determination—crop by acreage and yield, total western slaughter by western summer and western winter slaughter, summer pork production by summer slaughter and summer weight, winter pork production by winter slaughter and winter weight—the sums of the coefficients of determination amounted to 86, 96, 95, and 90 per cent, respectively. Thus about 9 per cent spurious determination is to be expected as the result of such conditions as inconsistencies in fitting the graphs, nonlinearity and nonadditive combination of effects. It follows that our fundamental hog variables, breeding and summer and winter prices, are probably really determined about 86 per cent on the average by the factors in the diagram instead of about 77 per cent as actually found by the foregoing analysis. It follows also that, all other factors combined, including such factors as the effects of epidemics of disease, can only determine from 14 to 23 per cent of the variation of these hog variables about their trends.

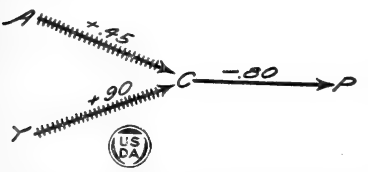

FIG. 28.—Diagram of the relations between corn acreage (*A*), yield (*Y*), crop (*C*), and price (*P*). The approximate values of the path coefficients are indicated

The relations between the corn variables are represented approximately in Figure 28.

In analysis of the corn situation for its own sake, it would be well to take account of the correlation between the acreage of successive years (+0.36) and possibly the indications of negative correlations between successive yields (−0.15), and crops (−0.20), as well as certain other obscure indications. There is probably also a slight degree of determination by the preceding hog situation. None of these relations have an important bearing on the hog situation, however, so that for the present purpose this simple scheme of relations is adequate. The crop is represented as completely determined by acreage and yield (12 per cent by acreage, 81 per cent by yield). Price is determined 64 per cent by crop, leaving 36 per cent residual. The theoretical correlations between crop and various hog variables in Figure 27 can be obtained by multiplying the corresponding price correlation by −0.80. Similarly, the theoretical correlations involving acreage and yield can be obtained by multiplying the crop correlation by +0.45 and +0.90, respectively.

SLAUGHTER AND LIVE WEIGHT

The western summer and winter slaughter and summer and winter live weight can be represented as determined by the amount of breeding and the size of the corn crop in the same and preceding years, with a reasonable degree of success. The path coefficients which have been found by repeated trials to give the closest approximation to the observed correlations are given in Table 11, primes being used as before to indicate preceding years.

TABLE 11.—*The path coefficients which measure the influence of variations in hog breeding and the corn crop in a period of three or four years on the variations in summer and winter live weight and summer and winter hog pack in a given year*

Factor	Summer weight	Winter weight	Summer pack	Winter pack
Breeding	+0.80	+0.35	−0.10	----------
Breeding′	+0.30	----------	+0.45	+0.85
Breeding″	−0.15	----------	+0.35	+0.35
Breeding‴	----------	----------	+0.35	+0.15
Corn crop	----------	+0.65	−0.25	−0.20
Corn crop′	----------	----------	+0.55	----------
Corn crop″	----------	----------	−0.10	----------

The use of corn crop in the present connection instead of corn price, used in connection with breeding and hog costs, is somewhat arbitrary. The fact, however, that crop shows at least as high maximum correlations with weight and pack as does price, indicates that the influence of corn on these hog variables is not exclusively through the mediation of price. It is not practicable to attempt to distinguish the direct influence of the crop from the indirect effect through price. The use of crop here serves to balance the greater influence attributed to price in the central system.

Summer weight has been used as an indicator of the amount of breeding during the year. The coefficient for the influence from the breeding of the current year is accordingly high (+0.80). It is necessary to assume, however, that there is considerable influence from the preceding year (+0.30). The way in which heavy breeding in the preceding fall as well as in the spring and fall of the current year increases live weight by increasing the percentage of old sows slaughtered has been discussed previously. The negative coefficient for the path from the breeding of the second preceding year (−0.15) measures the effect of an excess of hogs in reducing the feed available per head. For a similar reason one might expect a positive influence of the preceding and perhaps also current corn crop. The coefficient for such an effect can be of only very small importance, however, in view of the low correlations between crop and summer weight.

Summer weight is an even better indicator of current breeding than is brought out by the path coefficient of +0.80. The correlation resulting from the three factors above is +0.91. Summer weight is determined 92 per cent by these factors.

It was concluded in an earlier section that winter weight is determined primarily by the supply of corn and secondarily by the number of old sows slaughtered as the result of the breeding of the preceding spring. In harmony with these conclusions the most satisfactory approximations to the correlations involving winter weight were obtained by the assumption of paths of influence from the preceding fall corn crop and the breeding of the current year (spring and fall) with coefficients of +0.65 and +0.35, respectively. There is 61 per cent determination by these factors.

In order to fit the correlations involving summer slaughter it seems necessary that the latter be represented as influenced by the breeding of the current and three preceding years and the current and two preceding corn crops. The preceding corn crop is represented as having the most important direct effect (+0.55). The effect of crop on slaughter through the mediation of its stimulating effect on breeding is, of course, excluded from the effect measured by this coefficient. A direct effect of crop on slaughter of a given season can be due only to a redistribution of slaughter in time or place. Whatever increase there is in one season in the wholesale pack must be at the expense of the preceding or following seasons or of the country slaughter. In the present case there seems to be a concentration of slaughter in the summer following a big crop, due largely to holding back during the fall and winter preceding this summer and to a less extent from an advance from the slaughter of the winter following. The holding back from the preceding winter is represented as in part handed on from the preceding fall (−0.25), and the advance slaughter from the following winter is represented as wholly balanced by an advance from the following summer (−0.10). The reasons for the concentration of slaughter in the summer following a big crop, and the reverse after a small crop, have been discussed.

Winter slaughter is represented as affected most by the breeding one to two years before (+0.85). The breeding for the two years before, however, must also be assumed to have effects (+0.35, +0.15). As previously suggested, it is not the actual hogs resulting from the breeding of these earlier years which swell the winter slaughter in question, but the effect of a surplus of hogs in increasing the age of slaughter. The holding back in one year tends to cause a surplus in the next, and a repetition of the holding back.

Summer pack is not affected to so great an extent as winter pack by the breeding of any one year. It seems, however, to be affected almost equally by the three preceding years. The marked effect of the third preceding year (+0.35) was not expected but seems to be a necessary assumption in accounting for the correlations. The breeding of the current year naturally has a slight negative influence on the summer pack (−0.10).

The foregoing factors determine summer pack 74 per cent, and winter pack 79 per cent.

PORK PRODUCTION AND TOTAL WESTERN PACK

Summer and winter pork productions are simply the products of the pack and weight for the corresponding seasons. In round numbers the correlations involving summer pork production result from path coefficients of value, +0.95 from summer pack and +0.20 from summer weight. The corresponding path coefficients in the case of winter pork are +0.95 and +0.25, respectively. These coefficients give an apparent 90 per cent determination in the case of summer pork and 87 per cent in the case of winter pork.

The total annual western pack is the sum of the summer and following winter packs. In round numbers the path coefficients have the values +0.60 and +0.55, respectively, giving about 100 per cent determination.

TOTAL EASTERN PACK

The eastern pack occupies a rather isolated position among the variables discussed in this bulletin. In a general way its fluctuations are parallel to those of western pack, and the common influence of the factors determining the latter can be represented by a path coefficient leading from it. As pointed out, eastern pack is even more closely correlated with western hog price than is western pack. This was interpreted as due to an influence of western price on eastern shipments rather than of eastern supply on price. There is, in fact, a high correlation with the price of the preceding winter as well as with the prices of the summer and winter of the year in question. The following path coefficients were found by trial to give the best approximations to the correlations involving eastern pack.

Eastern pack

Western pack +0.25	Winter price′	−0.25
	Summer price	−0.25
	Winter price	−0.20

These four factors account for 56 per cent determination. The large residual variation is doubtless dependent on special eastern conditions not dealt with here.

FARM PRICE OF HOGS, JANUARY 1

The lag of farm price of hogs on the packer's price has been discussed. Path coefficients of +0.30 and +0.70 leading from the packing prices of the preceding summer and the current winter give a fairly satisfactory fit to its correlations and account for 86 per cent determination.

THE CORRELATIONS

The correlations which result from the foregoing system of path coefficients are easily calculated. Those within the central system are given in Table 9. The next step is to find the correlation between summer and winter slaughter and weight on the one hand and the variables in the central system, including crop, on the other. The correlation between winter weight and the crop of the preceding fall is, for example, $+0.35\, r_{BC}+0.65$. The remaining correlations can now be calculated directly. As an example, that between winter pack (*G*) and another variable (*X*) is obtained from the formula,

$$r_{XG}=+0.85\, r_{XB'}+0.35\, r_{XB''}+0.15\, r_{XB'''}-0.20\, r_{XC}$$

The correlations which result from the system of path coefficients are given in italic in Tables 3 to 6, inclusive, each following the corresponding observed correlation. The average difference between the observed and expected correlations (neglecting sign) is 0.09, which is about as good agreement as can reasonably be expected. The most serious discrepancies come in certain correlations involving corn acreage and yield, which were intentionally neglected for the sake of avoiding complexity in the relations among the more important variables. The degree of correspondence between observation and expectation for the more important variables is shown in Figures 16 to 25, inclusive. The observed correlations are shown as solid lines and the expected as dotted lines.

The assumed system of causal relations gives a fairly satisfactory explanation of the 510 observed correlations. Is it the only hypothetical system which could do this? A great many other central systems were tried. The writer started, for example, with the belief that there should be an important direct influence of western summer and winter wholesale packs on the prices paid by the packers for these same hogs. No scheme which embodied this conception was even approximately as successful as that here presented.[7] The same is true of all other systems tested. The successful system is based on the analysis of the factors which give the maximum percentage determination of each variable, according to Pearson's method of multiple correlation, rather than on preconceived ideas of what the relations ought to be. From this analysis and the numerous tests of other systems, the writer feels confident that no equally simple system can be found which differs substantially from the present and gives even approximately so good a fit to the observed correlations. Doubtless slight improvement can be effected by small modification in the value of the path coefficients or in the addition of minor paths. A slightly different interpretation could doubtless be given to some of the paths here adopted. The actions and reactions among the variables are necessarily too complex to be represented more than roughly by any simple diagram.

PREDICTION FORMULAS

The coefficient of correlation between two variables expresses the average amount which either one deviates from its trend on the occurrence of a given deviation of the other, provided that the deviation of each is measured in terms of its own standard deviation, or, theoretically, any other sort of average deviation. Thus, if the corn crop is an average amount above the trend, we find in Table 3 or Figure 16 that corn price is in general below its trend by 80 per cent of the average amount of its fluctuation. Similarly, after an average deviation of the corn crop, the hog pack of the next summer will be about 61 per cent of the average fluctuation above its trend. Thus every one of the correlations in Tables 3 to 6, inclusive, can be used as a prediction formula. In order to convert such a prediction formula, expressed in terms of average fluctuation, into actual units, it is of course merely necessary to multiply by the ratio of the standard deviations. The latter are given in Table 2 for the period from 1889 to 1913 and for the whole period 1871 to 1913 when the data were available.

For the probable deviation of X in terms of Y (regression of X on Y) we have

$$\mathrm{Reg}_{X\cdot Y} = r_{XY}\frac{\sigma_X}{\sigma_Y}$$

[7] It is, however, probable that a direct (negative) influence of pack on price could be represented with some improvement to the system, if a reaction (positive) of price on the same season's pack was also represented. With such a system of relations it can be shown that price may be more closely correlated with the factors back of pack than with pack itself. The treatment of such reciprocal relations between variables requires an extension of the theory of path coefficients. It will suffice here to point out that the relations between pack and price could probably be more accurately shown, but at the expense of considerable additional complexity in the system.

As an example take the case of corn crop and price.

$$\mathrm{Reg}_{P\cdot C} = r_{PC}\,\frac{\sigma_P}{\sigma_C}$$

$$= -0.80 \times \frac{8.3 \text{ cents per bushel}}{260{,}000{,}000 \text{ bushels}}$$

$$= -2.55 \text{ cents per } 100{,}000{,}000 \text{ bushels}$$

This means that every fluctuation of 100,000,000 bushels in the estimated corn crop during the period from 1871 to 1913 meant an

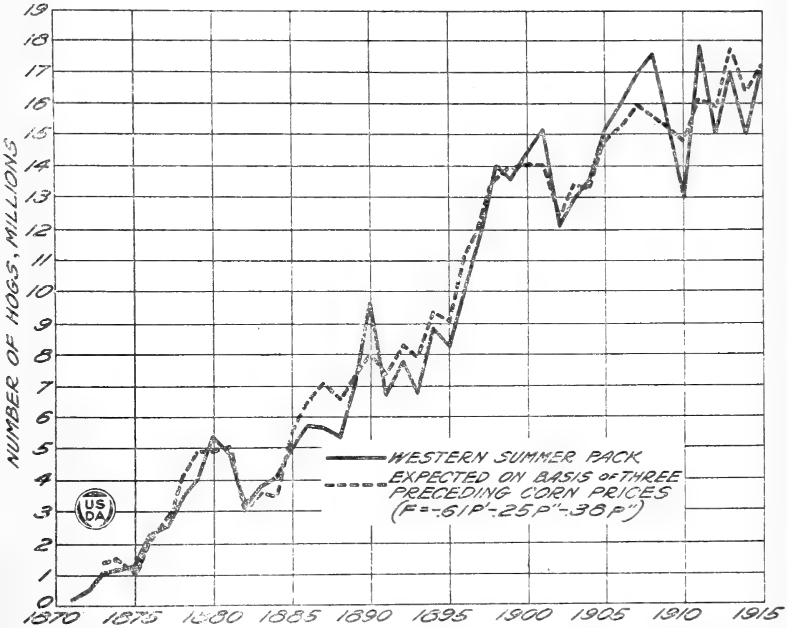

FIG. 29.—The actual western summer pack and the expected value on the basis of three preceding corn prices. The deviations from the corn-price trend in the successive years are multiplied by −.38, −.25, and −.61, respectively, and added. The result multiplied by the ratio of the standard deviation of western summer to corn price $\frac{(1171)}{8.3}$ is the expected deviation of the summer pack from its trend in the following year. Summer pack is determined 57 per cent by the three preceding corn prices

average fluctuation in the opposite direction of about 2.55 cents in the price of corn per bushel.

Similarly, every increase or decrease of 100,000,000 bushels in the corn crop during the same period meant in the average an increase or decrease of about 275,000 hogs in the wholesale western hog pack of the next summer.

The winter hog pack could have been predicted rather closely from the summer live weight a year and a half before, on the basis of the correlation of +0.78 between them. Every departure of 1 pound from the trend of summer live weight indicated in general a corresponding increase or decrease of 130,000 hogs in the second following winter pack (fig. 30).

Better predictions can be made by taking more than one variable into account. Theoretically this could be done from the path-coefficient formulas, multiplying each coefficient by the ratio of the standard deviation of the dependent variable to that of the causal factor in question. Many of these formulas, however, involve the amount of breeding, a factor for which we do not have measurements.

The best predictions can be obtained from the closely related multiple-regression coefficients. The more important prediction formulas of this sort are given in Table 12. It is assumed that each variable is measured in terms of its standard deviation. Predictions in terms of actual units can be obtained as before by multiplying each term by the ratio of the standard deviation of the required variable to that of the correlated variable to which the term applies. The accuracy of

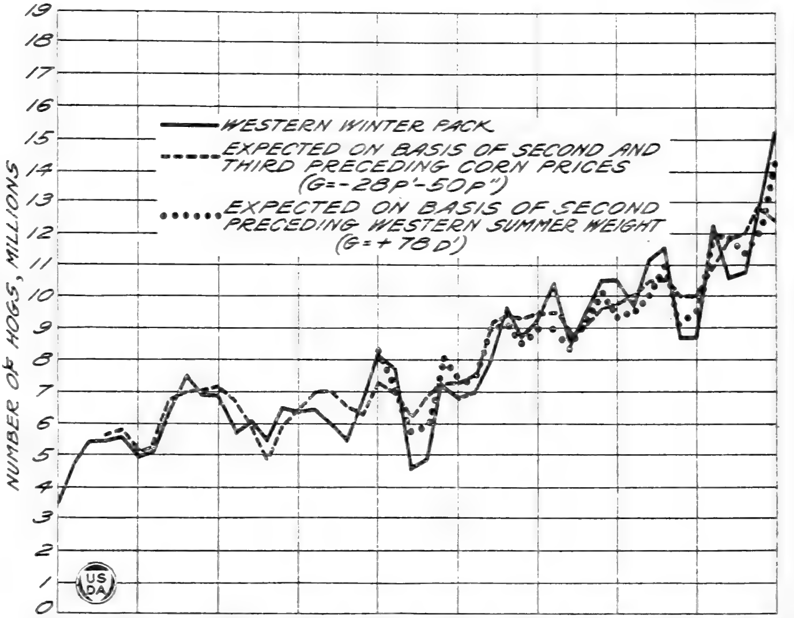

FIG. 30.—The actual western winter pack and that expected on the basis of the second and third preceding corn prices, and also that expected on the basis of the western summer live weight a year and a half before. There is only 36 per cent determination by these prices but 61 per cent determination by western summer live weight

the fit during the period in question is indicated by the percentage determinations at the right. Figure 29 shows the fairly successful predictions of summer pack which could have been made on the basis of preceding corn prices (57 per cent determination); Figure 30 shows the less successful predictions of winter pack on the basis of corn prices (36 per cent determination).

Table 13 gives a number of other multiple-regression formulas, which are not usable as prediction formulas since they involve contemporary variables but are of interest in forming a judgment of the causal relations.

The success of these formulas in predictions depends on the continuance of the relations on which they are based and also on the continuance of the general trends of the various quantities. Under ordinary conditions one is not likely to go far astray in projecting a trend for one or two years into the future and measuring the expected fluctuations from it. Conditions may arise, however, which make any prediction of this sort of little value. The World War, for example, caused a radical change in the price level as well as a disturbance of the normal relations among all the factors. Conditions which, as we have seen, had previously determined 70 or 80 per cent of the fluctuation of the hog and corn variables, suddenly became of minor importance, as new conditions came to dominate the situation.

The war conditions have not yet ceased to act. For the present, then, the system of relations and the prediction formulas are probably of little more than historic interest. In time, however, it is to be expected that conditions will again reach the stability essential for the success of predictions based on correlations. Formulas similar in form to those given here but with due regard to the current amount of fluctuation in the various quantities, should then become useful. Even under these conditions, however, caution is necessary. The system of relations among the variables is not a mechanically inevitable one. Fundamental changes may take place.

Hog prices are determined by a broader vision of the conditions than the mere number of hogs which are being received by the packers. The amount of breeding, on the other hand, seems to be determined more by the memory of past profits than by a sound judgment of those in prospect. The result is the cycle of successive overproduction and underproduction which is one of the dominating features of the hog situation. If means can be devised for obtaining a sounder estimate of prospective conditions the whole system of relations will need revision. The general use of prediction formulas would itself be a factor that would tend to modify the system of relations on which the predictions were based. This, indeed, would be the greatest good which they could bring about.

The variables in Tables 12 and 13 are represented by the following symbols, primes being used to represent those pertaining to a preceding year. The year is considered as beginning with the summer pack, March 1.

TABLE 12.—*Multiple regression equations*

WESTERN HOG PACK

Corn acreage (A)	Summer price (S)	Summer pack (F)	Western annual pack (J).
Corn yield (Y)	Winter price (W)	Winter pack (G)	Eastern annual pack (K).
Corn crop (C)	Summer weight (D)	Summer pork (H)	Farm price (Jan. 1.) (L).
Corn price (Dec. 1.) (P)	Winter weight (E)	Winter pork (I)	

SUMMER HOG PRICE

		Per cent
Corn crops	S= −0.48 C′ −0.07 C″	22
Corn prices	S= +0.64 P′ +0.24 P″	50
Crop and summer weights	S= −0.40 C′ −0.59 D′ −0.32 D″	69
Corn price and summer weights	S= +0.53 **P** −0.44 D′ −0.36 D″	76

WINTER HOG PRICE

Corn crops	W= −0.32 C −0.35 C′ −0.11 C″ +0.22 C′″	24
Corn prices	W= +0.39 P +0.48 P′ +0.23 P″ −0.27 P′″	55
Crops and summer weights	W= −0.25 C −0.08 C′ −0.38 D −0.63 D′	67
Corn prices and summer weights	W= +0.47 P +0.27 P′ −0.63 D′	71

TABLE 12.—*Multiple regression equations*—Continued

SUMMER WEIGHT

		Per cent
Corn crops	D= +0.32 C′ −0.13 C″ −0.31 C‴	24
Corn prices	D= −0.50 P′ +0.16 P″ +0.16 P‴	31
Crops and summer weights	D= +0.31 C′ −0.58 D″	47
Corn price and summer weights	D= −0.43 P′ −0.55 D″	55
Corn price, winter cost	D= −0.77 P′ +0.64 W′	60
Corn price, winter cost; Winter slaughter	D= −0.65 P′ +0.44 W′ −0.27 G′	63

WINTER WEIGHT

Corn crops	E= +0.61 C −0.09 C′ −0.06 C″ −0.29 C‴	49
Corn prices	E= −0.66 P +0.14 P′ −0.11 P″ +0.22 P‴	47
Crops and summer weight	E= +0.57 C +0.38 D	55
Crop, summer weight, summer pack	E= +0.52 C +0.39 D −0.21 F	59

SUMMER PACK

Corn crops	F= +0.71 C′ +0.40 C″ +0.33 C‴	57
Corn prices	F= −0.61 P′ −0.25 P″ −0.38 P‴	57
Crop and summer weights	F= +0.57 C′ +0.36 D′ +0.29 D″	59

WINTER PACK

Corn crops	G= +0.03 C +0.31 C′ +0.49 C″	27
Corn prices	G= +0.11 P −0.29 P′ −0.49 P″	37
Crops and summer weight	G= +0.12 C′ +0.19 C″ +0.69 D′	64
Corn price, winter cost	G= −0.67 P″ +0.38 W″	39
Weights	G= +0.17 E′ +0.64 D′ +0.26 E″	67

SUMMER PORK

Corn crops	H= +0.75 C′ +0.43 C″ +0.32 C‴	62
Corn prices	H= −0.74 P′ −0.26 P″ −0.40 P‴	76
Crops and summer weight	H= +0.58 C′ +0.42 D′ +0.16 D″	61
Corn price, summer cost	H= −0.72 P′ −0.37 S″	66

WINTER PORK

Corn crops	I= +0.25 C +0.40 C′ +0.49 C″	32
Corn prices	I= −0.08 P −0.37 P′ −0.49 P″	41
Crops and summer weight	I= +0.15 C′ +0.13 C″ +0.76 D′	72
Weights	I= +0.07 E′ +0.77 D′ +0.14 E″	71

TABLE 13.—*Multiple regression equations involving contemporary variables*

[The symbols have the same significance as those in Table 12]

CORN CROP

		Per cent
Acreage, yield	C= +0.34 A +0.81 Y	87

CORN PRICE

Acreage, yield	P= −0.21 A −0.73 Y	64

SUMMER HOG PRICE

Summer pork, winter pork:		
Preceding	S= −0.58 H −0.23 I′	45
Following	S= −0.47 H −0.25 I	44
Both	S= −0.19 I′ −0.46 H −0.20 I	47

WINTER HOG PRICE

Winter pork, summer pork:		
Preceding	W= −0.69 I +0.01 H	47
Following	W= −0.62 I −0.27 H	54

SUMMER PORK

Summer pack and weight	H= +0.96 F +0.19 D	95

WINTER PORK

Winter pack and weight	I= +0.96 G +0.25 E	90

TABLE 13.—*Multiple regression equations involving contemporary variables*—Con.

		Per cent
TOTAL WESTERN PACK		
Summer and winter pack	$J = +0.61\ F\ \ +0.53\ G$	100
TOTAL EASTERN PACK		
Western pack and hog prices	$K = +0.24\ J\ \ -0.22\ W'\ \ -0.25\ S\ \ -0.20\ W$	56
FARM PRICE JANUARY 1		
Packers' prices	$L = +0.70\ W\ \ +0.29\ S$	85

SUMMARY

An attempt to analyze the play of interacting factors responsible for the annual fluctuations in production and price of hogs during the period of relatively stable conditions between the Civil War and the World War is made in this bulletin. It is shown that variations in the corn crop and certain interrelations among the hog variables themselves determine from 75 to 85 per cent of the variations of the latter. The factors dealt with are listed in the next paragraph. It is recognized that there are important external factors other than the corn situation which are not dealt with.

The annual fluctuations about the trend during the period of years from 1871 to 1915, inclusive (so far as data were available), have been found for corn acreage, yield, crop, and price and for the western and eastern wholesale hog packs and the farm price of hogs. The fluctuations for the summer and winter seasons separately have been found for the western wholesale hog pack, and the corresponding average live weight, pork production, and price.

All the possible correlations among these variables have been calculated (Tables 3 to 6, figs. 16 to 25, inclusive).

An attempt has been made to find the system of causal relations that would account best for the observed correlations. Path coefficients have been calculated for each path of influence in this system, from which the expected value of each of the 510 correlations has been found.

A series of formulas is given for predicting the fluctuations of each variable, with discussions of the limitations. The following general conclusions are reached:

The dominating features of the hog situation are certain effects of the corn crop and price and an innate tendency to fall into a cycle of successive overproduction and underproduction, two years from one extreme to the other.

The amount of breeding at a given time is determined largely by the profits from hog raising during the preceding year, which depends on the ratio between the price the packers pay for the hogs and the price of corn during the period in which they were raised and finished. The peak effect on breeding occurs from half a year to a year after the hog-corn price ratio has reached its peak and begun to decline. The result is a surplus of hogs a year or more later, low prices, and losses. Breeding, however, does not reach its low point until some time after the hog-corn price ratio has begun to rise. A swing to underproduction is the consequence. Thus any cause which leads to unusual profits or losses tends to set up oscillations in the hog population, four years from crest to crest. In order to eliminate these unfortunate oscillations, hog breeding must be based on a sounder vision of prospective conditions than can be obtained from the memory of past profits.

The average price which the packers pay for hogs during a given season depends less on the actual supply offered them than on the current and prospective conditions in the country as a whole, as indicated by past breeding and current and past corn prices. The interactions among the corn and hog prices and hog breeding, around which the whole hog situation centers, are given in more detail in Figure 27.

The summer live weight is for various reasons a remarkably close indicator of the amount of breeding for the period from the preceding through the following fall. It shows higher correlations on the whole with other hog variables than any other variable dealt with, although the least affected by corn prices. Thus winter slaughter and pork production could have been predicted with remarkable accuracy during the period studied from knowledge of the summer weight of a year and a half before (correlations of +0.78 and +0.83, respectively). In general, the best predictions could have been made on the basis of preceding summer weights and corn prices.

Winter live weight, on the contrary, is determined largely by the preceding corn crop and only secondarily by the amount of breeding during the preceding year.

Seasonal slaughter is determined in part by the amount of breeding during at least three years preceding and in part by a tendency toward concentration in the summer season, in which prices are high, at the expense of the winter, whenever the corn supply permits. The corn crop has its maximum effect on slaughter in the following summer, largely as the result of the latter cause. There is a second peak of slaughter in the third following winter due to the stimulus to breeding.

Pork production depends very much more on the fluctuations in slaughter than on the relatively small percentage fluctuations in weight.

The eastern pack runs parallel to the western in most respects. The influence of corn crop and prices is considerably less. Western hog prices, on the other hand, are even more closely correlated with the eastern than with the western pack, probably owing to their influence on eastern shipments.

The farm price of hogs is very closely correlated with the packers' price but seems to lag behind several months.

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